Results of Proficiency Test
Liquefied Propane &
Sulfur (total) in LPG
October 2020

Organized by: Institute for Interlaboratory Studies
Spijkenisse, the Netherlands

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1 INTRODUCTION

Since 2009 the Institute for Interlaboratory Studies (iis) organizes a proficiency scheme for the analysis of Liquefied Propane every year. From 2017 onwards a proficiency scheme for the analysis of Sulfur (total) in LPG is organized every year as well. During the annual proficiency testing program 2020/2021 it was decided to continue the round robin for both the analysis of Liquefied Propane and for the analysis of Sulfur (total) in LPG.

Because iis has limited gas-handling facilities in place to prepare gas samples, a co-operation with EffecTech (Uttoxeter, United Kingdom) was set up for the Liquefied Propane PT (iis20S03P) and a co-operation with Nippon Gases (Belgium) was set up for the Sulfur (total) in LPG PT (iis20S03S). Both EffecTech and Nippon Gases are fully equipped and have experience in the preparation of gas mixtures.
In the interlaboratory studies for Liquefied Propane 47 laboratories in 28 different countries and for Sulfur (total) in LPG 33 laboratories in 20 different countries registered for participation. In this report, the results of the proficiency tests Liquefied Propane and Sulfur (total) in LPG are presented and discussed. This report is also electronically available through the iis website www.iisnl.com.

2 SET UP

The Institute for Interlaboratory Studies (iis) in Spijkenisse, the Netherlands, was the organizer of this proficiency test (PT). In this proficiency test, the participants received, depending on the registration, one or two samples, see table below.

PT	Sample ID	Sample	Size	Purpose
iis20S03P	#20200	Liquefied Propane mixture	one cylinder of 1L	Composition and Physical properties
iis20S03S	#20201	LPG mixture with DMS	one cylinder of 5L	Total Sulfur

Table 1: samples used in Liquefied Propane PT and in Sulfur (total) in LPG PT

The limited cylinder sizes (1L and 5L) are chosen to optimize sample stability, cylinder costs, transport and handling costs.
Participants were requested to report rounded and unrounded test results. The unrounded test results were preferably used for statistical evaluation.

2.1 QUALITY SYSTEM

The Institute for Interlaboratory Studies in Spijkenisse, the Netherlands, has implemented a quality system based on ISO/IEC17043:2010. This ensures strict adherence to protocols for sample preparation and statistical evaluation and 100% confidentiality of participant's data. Feedback from the participants on the reported data is encouraged and customer's satisfaction is measured on regular basis by sending out questionnaires.
EffecTech is accredited in conformance with ISO/IEC17043:2010 by UKAS (no. 4719) and ISO17025:2005 by UKAS (no. 0590). Nippon Gases is accredited in conformance with ISO 9001:2015 and ISO 14001.

2.2 PROTOCOL

The protocol followed in the organization of this proficiency test was the one as described for proficiency testing in the report 'iis Interlaboratory Studies: Protocol for the Organisation, Statistics and Evaluation' of June 2018 (iis-protocol, version 3.5). This protocol is electronically available through the iis website www.iisnl.com, from the FAQ page.

2.3 CONFIDENTIALITY STATEMENT

All data presented in this report must be regarded as confidential and for use by the participating companies only. Disclosure of the information in this report is only allowed by means of the entire report. Use of the contents of this report for third parties is only allowed by written permission of the Institute for Interlaboratory Studies. Disclosure of the identity of one or more of the participating companies will be done only after receipt of a written agreement of the companies involved.

2.4 SAMPLES

For the liquefied Propane mixture it was decided to prepare a uniquely coded 1L cylinder to optimize the costs for the participants. The mixture was divided over a batch of 56 cylinders (with dip tube device) and tested for homogeneity by EffecTech (Uttoxeter, United Kingdom) in conformance with ISO guide 35:2006 and ISO17025:2017 (job 20/0953). Each cylinder was filled with approximately 200 grams of Liquefied Propane mixture and labelled #20200. Every cylinder in the batch was analyzed using replicate measurements. The within bottle and between bottle variations were assessed in accordance with ISO Guide 35:2006. This evaluation showed that all between bottle variations were small compared to the uncertainties on the reference values on each component.
The repeatability values (r) were calculated per component by multiplication of the respective standard deviation by 2.8. Subsequently, the calculated repeatabilities were compared with 0.3 times the corresponding reproducibility of the reference method in agreement with the procedure of ISO13528, Annex B2 in the next table.

	r (observed) in %mol/mol	0.3 * R (D2163:14(2019)) in %mol/mol
Ethane	0.0009	0.0341
Propane	0.0223	1.2380
Propene	0.0038	0.0733
iso-Butane	0.0104	0.0756
n-Butane	0.0087	0.0648
1-Butene	0.0009	0.0199
iso-Butene	0.0009	0.0236
n-Pentane	0.0039	0.0268

Table 2: homogeneity test results of subsamples #20200

The calculated repeatabilities were in agreement with 0.3 times the corresponding reproducibility of the reference test method. Therefore, homogeneity of the subsamples was assumed.

For the Sulfur (total) in LPG sample a batch of 34 uniquely coded 5L cylinders (with dip tube device) was prepared and tested for homogeneity by Nippon Gases (Belgium) in conformance with ISO9001 and ISO14001 (ref. nr. 416.059.001; order nr. 308578 – Total Sulphur). Each cylinder was filled with approximately 1500 grams of LPG and spiked with Dimethyl Sulfide (DMS) and labelled #20201.
The repeatability of the determination of Total Sulfur for all cylinders were calculated by multiplication of the deviation by 2.8. Subsequently, the calculated repeatability was compared with 0.3 times the corresponding reproducibility of the reference method in agreement with the procedure of ISO13528, Annex B2 in the next table.

	Total Sulfur in mg/kg
r (observed)	2.1
reference test method	ASTM D6667:14(2019)
0.3 * R (ref. test method)	3.2

Table 3: evaluation of the repeatability of subsamples #20201

The calculated repeatability was in agreement with 0.3 times the reproducibility of the reference test method. Therefore, homogeneity of the subsamples was assumed.

Depending on the registration to each of the participating laboratories 1 cylinder of Liquefied Propane labelled #20200 and/or 1 cylinder with Sulfur in LPG labelled #20201 was sent on September 23, 2020. An SDS was added to the sample package.

2.5 STABILITY OF THE SAMPLES

EffecTech (Uttoxeter, United Kingdom) and Nippon Gases (Belgium) declare that the prepared gas cylinders have a shelf life of at least 6 months. This is sufficient for the proficiency testing purposes.

2.6 ANALYZES

The participants were requested to determine on sample #20200: Ethane, Propane, Propene, iso-Butane, n-Butane, 1-Butene, iso-Butene, n-Pentane, iso-Pentane, Molar Mass, Relative Density at 60/60°F, Absolute and Relative Vapor pressure at 100°F, Absolute and Relative Vapor pressure at 40°C, Motor Octane Number (MON), Ideal Gross Heating Value and Ideal Net Heating Value at 14.696 psia and 60°F.
The participants were requested to determine on sample #20201: Total Sulfur.

It was explicitly requested to treat the sample as if it was a routine sample and to report the test results using the indicated units on the report form and not to round the test results, but report as much significant figures as possible. It was also requested not to report ‘less than’ test results, which are above the detection limit, because such test results cannot be used for meaningful statistical evaluations.

To get comparable test results a detailed report form and a letter of instructions are prepared. On the report form the reporting units are given as well as the reference test methods (when applicable) that will be used during the evaluation. The detailed report form

and the letter of instructions are both made available on the data entry portal www.kpmd.co.uk/sgs-iis/. The participating laboratories are also requested to confirm the sample receipt on this data entry portal. The letter of instructions can also be downloaded from the iis website www.iisnl.com.

3 RESULTS

During five weeks after sample dispatch, the test results of the individual laboratories were gathered via the data entry portal www.kpmd.co.uk/sgs-iis/. The reported test results are tabulated per determination in appendix 1 of this report. The laboratories are presented by their code numbers.

Directly after the deadline, a reminder was sent to those laboratories that had not reported test results at that moment. Shortly after the deadline, the available test results were screened for suspect data. A test result was called suspect in case the Huber Elimination Rule (a robust outlier test) found it to be an outlier. The laboratories that produced these suspect data were asked to check the reported test results (no reanalyzes). Additional or corrected test results are used for data analysis and the original test results are placed under 'Remarks' in the result tables in appendix 1. Test results that came in after the deadline were not taken into account in this screening for suspect data and thus these participants were not requested for checks.

3.1 STATISTICS

The protocol followed in the organization of this proficiency test was the one as described for proficiency testing in the report ‘iis Interlaboratory Studies: Protocol for the Organisation, Statistics and Evaluation’ of June 2018 (iis-protocol, version 3.5).
For the statistical evaluation the *unrounded* (when available) figures were used instead of the rounded test results. Test results reported as ‘<…’ or ‘>…’ were not used in the statistical evaluation.

First, the normality of the distribution of the various data sets per determination was checked by means of the Lilliefors-test, a variant of the Kolmogorov-Smirnov test and by the calculation of skewness and kurtosis. Evaluation of the three normality indicators in combination with the visual evaluation of the graphic Kernel density plot, lead to judgement of the normality being either ‘unknown’, ‘OK’, ‘suspect’ or ‘not OK’. After removal of outliers, this check was repeated. If a data set does not have a normal distribution, the results of the statistical evaluation should be used with due care.

According to ISO5725 the original test results per determination were submitted to Dixon’s, Grubbs’ or Rosner’s outlier tests. Outliers are marked by D(0.01) for the Dixon’s test, by G(0.01) or DG(0.01) for the Grubbs’ test and by R(0.01) for the Rosner’s test. Stragglers are marked by D(0.05) for the Dixon’s test, by G(0.05) or DG(0.05) for the Grubbs’ test and by R(0.05) for the Rosner’s test. Both outliers and stragglers were not included in the calculations of averages and standard deviations.

For each assigned value the uncertainty was determined in accordance with ISO13528. Subsequently the calculated uncertainty was evaluated against the respective requirement

based on the target reproducibility in accordance with ISO13528. In this PT, the criterion of ISO13528, paragraph 9.2.1. was met for all evaluated tests, therefore, the uncertainty of all assigned values may be negligible and need not be included in the PT report.

Finally, the reproducibilities were calculated from the standard deviations by multiplying them with a factor of 2.8.

3.2 GRAPHICS

In order to visualize the data against the reproducibilities from literature, Gauss plots were made, using the sorted data for one determination (see appendix 1). On the Y-axis the reported test results are plotted. The corresponding laboratory numbers are on the X-axis.

The straight horizontal line presents the consensus value (a trimmed mean). The four striped lines, parallel to the consensus value line, are the +3s, +2s, -2s and -3s target reproducibility limits of the selected reference test method. Outliers and other data, which were excluded from the calculations, are represented as a cross. Accepted data are represented as a triangle.

Furthermore, Kernel Density Graphs were made. This is a method for producing a smooth density approximation to a set of data that avoids some problems associated with histograms. Also, a normal Gauss curve was projected over the Kernel Density Graph for reference.

3.3 Z-SCORES

To evaluate the performance of the participating laboratories the z-scores were calculated. As it was decided to evaluate the performance of the participants in this proficiency test (PT) against the literature requirements, e.g. ASTM, ISO or EN reproducibilities, the z-scores were calculated using a target standard deviation. This results in an evaluation independent of the variation in this interlaboratory study.

The target standard deviation was calculated from the literature reproducibility by division with 2.8. In case no literature reproducibility was available, other target values were used, like Horwitz or an estimated reproducibility based on former iis proficiency tests.

When a laboratory did use a test method with a reproducibility that is significantly different from the reproducibility of the reference test method used in this report, it is strongly advised to recalculate the z-score, while using the reproducibility of the actual test method used, this in order to evaluate whether the reported test result is fit-for-use.

The z-scores were calculated according to:

$$z_{(target)} = (\text{test result} - \text{average of PT}) / \text{target standard deviation}$$

The $z_{(target)}$ scores are listed in the test result tables in appendix 1.

Absolute values for z<2 are very common and absolute values for z>3 are very rare. Therefore, the usual interpretation of z-scores is as follows:

	|z|	< 1	good
1 <	|z|	< 2	satisfactory
2 <	|z|	< 3	questionable
3 <	|z|		unsatisfactory

4 EVALUATION

In this interlaboratory study some problems were encountered with the dispatch of the samples due to the COVID-19 pandemic. Therefore, the reporting time on the data entry portal was extended with another week.
For the Liquefied Propane PT (iis20S03P) four participants reported after the extended reporting date and four participants did not report any test results. Not all participants were able to report test results for all requested tests.
In total 43 participants reported 550 numerical test results. Observed were 35 outlying test results, which is 6.4%. In proficiency studies outlier percentages of 3% - 7.5% are quite normal.
For the Sulfur in LPG PT (iis20S03S) three participants reported after the extended reporting date and five participants did not report any test results. In total 28 participants reported 28 numerical test results. Observed were 4 outlying test results, which is 14.3%. In proficiency studies outlier percentages of 3% - 7.5% are quite normal.

Not all original data sets proved to have normal Gaussian distribution. These are referred to as “not OK” or “suspect”. The statistical evaluation of these data sets should be used with due care, see also paragraph 3.1.

4.1 EVALUATION PER SAMPLE AND PER TEST

In this section the reported test results are discussed per sample and per test. The test methods which were used by the various laboratories were taken into account for explaining the observed differences when possible and applicable. These test methods are also in the tables together with the original data. The abbreviations, used in these tables, are explained in appendix 3.

In the iis PT reports, ASTM methods are referred to with a number (e.g. D2163) and an added designation for the year that the method was adopted or revised (e.g. D2163:14). If applicable, a designation in parentheses is added to designate the year of reapproval (e.g. D2163:14(2019)). In the test results tables of appendix 1 only the method number and year of adoption or revision (e.g. D2163:14) will be used.

Because the majority of the participating laboratories used ASTM D2163 as test method for the determination of the Propane Composition, it was decided to use the reproducibilities of this test method as target reproducibilities, and to mention the reproducibilities of EN27941 (identical to IP405 and ISO7941) for reference only. In ASTM D2163 no reproducibilities of 1-Butene and iso-Butene are mentioned, the reproducibilities of n-Butane were used to calculate the reproducibilities of these two components.

Three laboratories (495, 1135 and 6203) reported deviating test results for many of the gas composition test results. At least four of the nine test results were statistical outliers. As the nine test results are not independent it was decided not to use any of the reported results of these laboratories for the statistical evaluation. This means that the remaining reported test results were excluded. Also, the reported test results for the parameters calculated from the measured Gas Composition were excluded for these laboratories.
Furthermore, two other laboratories (1011 and 6193) had a large deviation for the sum of the composition results. Since the composition was not normalized the calculated parameters were excluded for the statistical evaluation, when not marked as a statistical outlier.

sample #20200

Ethane: The determination of this component was not problematic. One statistical outlier was observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14(2019) and in agreement with the reproducibility requirements of EN27941:93(liq).

Propane: The determination of this component was not problematic. Two statistical outliers were observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14(2019) but is not in agreement with the reproducibility requirements of EN27941:93(liq).

Propene: The determination of this component was not problematic. Two statistical outliers were observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14(2019) and in agreement with the reproducibility requirements of EN27941:93(liq).

iso-Butane: The determination of this component was problematic. Three statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is not in agreement with the requirements of ASTM D2163:14(2019) and is not in agreement with the reproducibility requirements of EN27941:93(liq).

n-Butane: The determination of this component was problematic. Six statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is not in agreement with the requirements of ASTM D2163:14(2019) but is in agreement with the reproducibility requirements of EN27941:93(liq).

1-Butene: The determination of this component was not problematic. Two statistical outliers were observed and one other test results was excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14(2019) and in agreement with the reproducibility requirements of EN27941:93(liq).

iso-Butene: The determination of this component was not problematic. Four statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is in agreement with the requirements of ASTM D2163:14(2019) and in agreement with the reproducibility requirements of EN27941:93(liq).

n-Pentane: The determination of this component was very problematic. Six statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is not at all in agreement with the requirements of ASTM D2163:14e1(2019). Therefore, it was decided to calculate no z-scores. The calculated reproducibility after rejection of the statistical outliers is in agreement with the reproducibility requirements of EN27941:93(liq).

iso-Pentane: The determination of this component may not be problematic. Most of the laboratories agreed that the amount of iso-Pentane was lower than 0.01 %mol/mol, therefore no z-scores were calculated.

Total of the composition results: The sum of the test results of the composition per laboratory was calculated by iis. Since the composition results are requested as normalized, every laboratory should have an outcome of 100%. Two calculated results were found to be significantly different than 100. It was decided to exclude these test results in the evaluations of the Physical Properties.

Molar Mass: This calculated parameter may not be problematic. One statistical outlier was observed and three other test results were excluded. The calculated reproducibility after rejection of the suspect data is in line with the calculated reproducibility using the published molar mass factors obtained from ASTM D2421:19 over all reported component concentrations (0.18 vs. 0.17 g/mol).

Rel. Density at 60°F: This calculated parameter may not be problematic. Two statistical outliers were observed and three other test result were excluded. The calculated reproducibility after rejection of the suspect data is in line with the calculated reproducibility using the published relative density factors obtained from ASTM D2598:16 over all reported component concentrations (0.0012 vs. 0.0010).

Abs. VP at 100°F: As the reported results calculated via ISO8973 and ASTM D2598 are not identical, it was decided to evaluate the test results for both methods separately.
ISO8973; This calculated parameter may be problematic. One statistical outlier was observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is larger than the calculated reproducibility using the published vapor pressure factors obtained from ISO8973:97 over all reported component concentrations (3.08 vs. 1.40 psi).

ASTM D2598; This calculated parameter may be problematic. No statistical outliers were observed but one test result was excluded. The calculated reproducibility after rejection of the suspect data is larger than the calculated reproducibility using the published vapor pressure factors obtained from ASTM D2598:16 over all reported component concentrations (3.53 vs. 1.73 psi).

Rel. VP at 100°F: As the reported results calculated via ISO8973 and ASTM D2598 are not identical, it was decided to evaluate the test results for both methods separately.
ISO8973; This calculated parameter may not be problematic. One statistical outlier was observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is in line with the calculated reproducibility using the published vapor pressure factors obtained from ISO8973:97 over all reported component concentrations (1.03 vs. 1.40 psi).
ASTM D2598; This calculated parameter may be problematic. One statistical outlier was observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data is larger than the calculated reproducibility using the published vapor pressure factors obtained from ASTM D2598:16 over all reported component concentrations (2.89 vs. 1.73 psi).

Abs. VP at 40°C: This determination may be problematic. No statistical outliers were observed but four test results were excluded. The calculated reproducibility after rejection of the suspect data is larger than the calculated reproducibility using the published vapor pressure factors obtained from ISO8973:97 over all reported component concentrations (18.2 vs. 9.9 kPa).

Rel. VP at 40°C: This determination may be problematic. One statistical outlier was observed and four other test results were excluded. The calculated reproducibility after rejection of the suspect data is larger than with the calculated reproducibility using the published vapor pressure factors obtained from ISO8973:97 over all reported component concentrations (12.8 vs. 9.9 kPa).

MON: As the reported results calculated via EN589 and ASTM D2598 are not identical, it was decided to evaluate the test results for both methods separately.
EN589; This calculated parameter may be problematic. Three statistical outliers were observed and three other test results were excluded. The calculated reproducibility after rejection of suspect data is larger than the calculated reproducibility using the published vapor pressure factors obtained from EN589:18 over all reported component concentrations (0.33 vs. 0.07).
D2598; Due to the low number of reported test results it was decided to drawn no conclusions.

Ideal Gross Heating Value at 14.696 psia / 60°F: In this PT none of the participants reported to have used ISO6976, therefore the results for all laboratories were only calculated according to ASTM D3588.
This calculated parameter may be problematic. No statistical outlier was observed but one test result was excluded. The calculated reproducibility after rejection of the suspect data is in larger than the calculated reproducibility using the published Ideal Gross Heating Values obtained from EN3588:98(2017) over all reported component concentrations (12 vs. 8).

Ideal Net Heating Value at 14.696 psia / 60°F: In this PT none of the participants reported to have used ISO6976, therefore the results for all laboratories were only calculated according to ASTM D3588.
This calculated parameter may be problematic. No statistical outlier was observed but one test result was excluded. The calculated reproducibility after rejection of the suspect data is in larger than the calculated reproducibility using the published Ideal Gross Heating Values obtained from EN3588:98(2017) over all reported component concentrations (12 vs. 7).

sample #20201

Total Sulfur: The determination of this component was problematic. Four statistical outliers were observed. The calculated reproducibility after rejection of the outliers is not in agreement with the requirements of ASTM D6667:14(2019).

4.2 PERFORMANCE EVALUATION FOR THE GROUP OF LABORATORIES

A comparison has been made between the reproducibility as declared by the reference test method and the reproducibility as found for the group of participating laboratories. The number of significant test results, the average, the calculated reproducibility (2.8 * standard deviation) and the target reproducibility derived from literature reference test methods (in casu ASTM D2163) or based on previous proficiency tests are presented in the next table.

Component	unit	n	average	2.8 * sd	R(D2163)	R(EN27941) liq.-inj.
Ethane	%mol/mol	39	0.194	0.057	0.111	0.301
Propane	%mol/mol	40	91.84	1.28	4.12	1.02
Propene	%mol/mol	39	0.779	0.106	0.241	0.215
iso-Butane	%mol/mol	40	2.926	0.465	0.254	0.389
n-Butane	%mol/mol	37	2.817	0.370	0.219	0.389
1-Butene	%mol/mol	40	0.203	0.034	0.067	0.161
iso-Butene	%mol/mol	39	0.289	0.055	0.079	0.161
n-Pentane	%mol/mol	37	0.939	0.321	(0.091)*	(0.313)*
iso-Pentane	%mol/mol	27	<0.01	n.e.	n.e.	n.e.

Table 4: reproducibilities of the composition of sample #20200

*) results in brackets should be used with due care

Parameter	unit	n	average	2.8 * sd	R(all calc.)*
Molar Mass	g/mol	21	45.19	0.18	0.17
Rel. Density at 60/60°F		22	0.5135	0.0012	0.0010
Abs. VP at 100°F ISO/IP	psi	8	183.2	3.1	1.4
Abs. VP at 100°F D2598	psi	7	179.6	3.5	1.7
Rel. VP at 100°F ISO/IP	psi	8	168.1	1.0	1.4
Rel. VP at 100°F D2598	psi	12	164.4	2.9	1.7
Abs. VP at 40°C	kPa	20	1295	18	10
Rel. VP at 40°C	kPa	19	1193	13	10
MON EN589		11	95.05	0.33	0.07
MON D2598		5	96.24	(0.62)**	0.09
IGHV D3588	kJ/mol	11	2269	12	8
INHV D3588	kJ/mol	11	2088	12	7

Table 5: reproducibilities of calculated parameters on sample #20200 using one set of factors.

*) calculation based on all reported composition results
**) results in brackets should be used with due care

Component	unit	n	average	2.8 * sd	R(lit)
Total Sulfur	mg/kg	24	31.8	13.6	9.9

Table 6: reproducibility of test on sample #20201

Without further statistical calculations it can be concluded that for several components there is not a good compliance of the group of participating laboratories with the relevant reference test method. The problematic components have been discussed in paragraph 4.1.

4.3 COMPARISON OF THE PROFICIENCY TEST OF OCTOBER 2020 WITH PREVIOUS PTS

	October 2020	October 2019	October 2018	October 2017	October 2016
Number of reporting laboratories	43	46	44	47	43
Number of test results	550	574	495	536	472
Number of statistical outliers	35	48	20	30	34
Percentage of statistical outliers	6.4%	8.4%	4.0%	5.6%	7.2%

Table 7: comparison with previous proficiency tests on Liquefied Propane (excluded Sulfur in LPG)

	October 2020	October 2019	October 2018	October 2017
Number of reporting laboratories	28	13	15	8
Number of test results	28	13	15	8
Number of statistical outliers	4	0	1	1
Percentage of statistical outliers	14.3%	0%	6.7%	12.5%

Table 8: comparison with previous proficiency tests on Sulfur in LPG only

In proficiency tests, outlier percentages of 3% - 7.5% are quite normal.
The performance of the determinations of the proficiency tests was compared against the requirements of the reference test methods. The conclusions are given the following tables.

Component	October 2020	October 2019	October 2018	October 2017	October 2016
Ethane	+	+	++	++	++
Propane	++	++	++	++	++
Propene	++	++	++	++	++
iso-Butane	-	+	-	+/-	-
n-Butane	-	+/-	--	-	-
1-Butene	--	++	+	++	++
iso-Butene	-	+	+	++	+
n-Pentane	(--)	+/-	-	-	-
iso-Pentane	n.e.	n.a.	n.a.	n.a.	n.a.

Table 9: comparison determinations on Liquefied Propane against the reference test methods

**) results in brackets should be used with due care

Component	October 2020	October 2019	October 2018	October 2017
Total Sulfur	-	+	-	+

Table 10: comparison determinations on Sulfur in LPG against the reference test method

The following performance categories were used:

++: group performed much better than the reference test method
+ : group performed better than the reference test method
+/-: group performance equals the reference test method
- : group performed worse than the reference test method
-- : group performed much worse than the reference test method
n.e.: not evaluated

5 DISCUSSION

The consensus values as determined in this PT are compared with the average values from the homogeneity testing by EffecTech (Uttoxeter, United Kingdom) in the following table. From this comparison it is clear that most consensus values as determined in this PT are very well in line with the values as determined during the preparation of the gas cylinders.

Parameter	Average by EffecTech in %mol/mol	Average from participants in %mol/mol	Difference in %mol/mol	z-score
Ethane	0.201	0.194	0.007	0.19
Propane	92.005	91.843	0.162	0.11
Propene	0.792	0.778	0.014	0.16
iso-Butane	2.884	2.926	-0.042	-0.46
n-Butane	2.727	2.817	-0.090	-1.15
1-Butene	0.198	0.203	-0.005	-0.19
iso-Butene	0.288	0.289	-0.001	-0.02
n-Pentane	0.904	0.939	-0.034	(-1.06)*

Table 11: comparison of consensus values with values determined by EffecTech

*) results in brackets should be used with due care

In principle no additional variation should be introduced when applying a calculation on the reported component concentrations. However, in practice a significant additional uncertainty is added in most cases. See the differences between the values from the test results as reported by the participating laboratories (each using its own calculation procedure) and the values as calculated by iis using one calculation procedure for each set of laboratory test results (see table 5).
Different test methods for the calculation of the Vapor Pressure do exist. Specification EN589 refers to ISO8973 for the calculation of Vapor Pressure. In ISO8973 (identical to IP432) the Vapor Pressure is calculated from the mole fraction per component and a Vapor Pressure factor of that component (given for all components). In ASTM D2598 the Vapor Pressure is calculated from the liquid volume percentage per component and a Vapor Pressure factor of that component (given for only some components).
For the MON, the calculation in Annex B from specification EN589 is used by iis on a molar basis, while ASTM D2598 describes the calculation of MON on a liquid volume basis.
Also, the selection of the tables for the component factors to be used for the calculations may cause additional uncertainty.

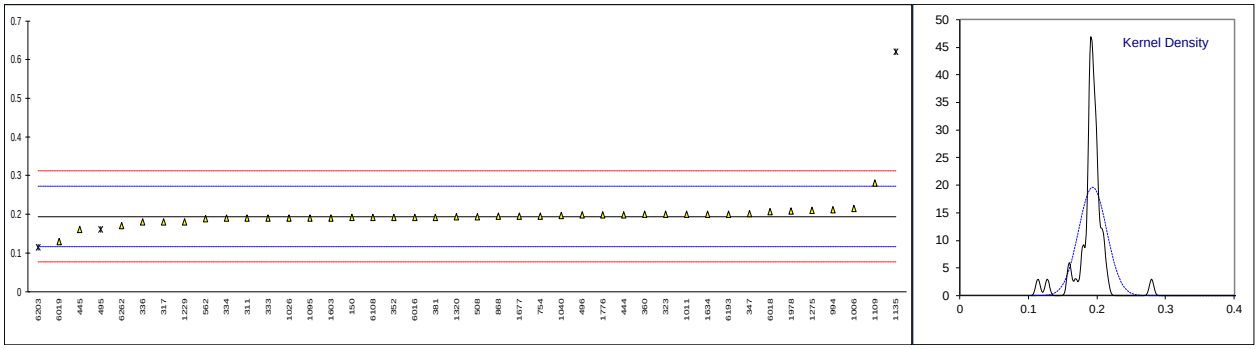
It is remarkable to see that the results for Vapor Pressure from the ASTM D2598 calculation are significantly lower than the results from the ISO8973/IP432 calculation.
The observed difference is caused by a difference in the VP factor of Ethane. ASTM (Subcommittee D02.H) commented (see also lit. 14):

"*The vapor pressure of ethane in D2598 was revised a few times prior to 2002. The current value, 611 psi, has remained the same for the last ten years. The revision of ethane was done because components in LPG blends do not necessarily behave as ideal gases. In particular, properties of ethane and ethylene appear to differ from ideality. Factors for these two components have been modified from 'ideal gas' values to make the calculated vapor pressure results more closely approximate actual measured vapor pressures of LPG blends. (i.e. D1267). Chapter 2 of Fuels and Lubricants Handbook (George Totten, © 2003), states that calculated vapor pressure were found to be biased high relative to experimental vapor pressure measured by D1267 for high ethane samples in earlier versions of D2598*".

APPENDIX 1

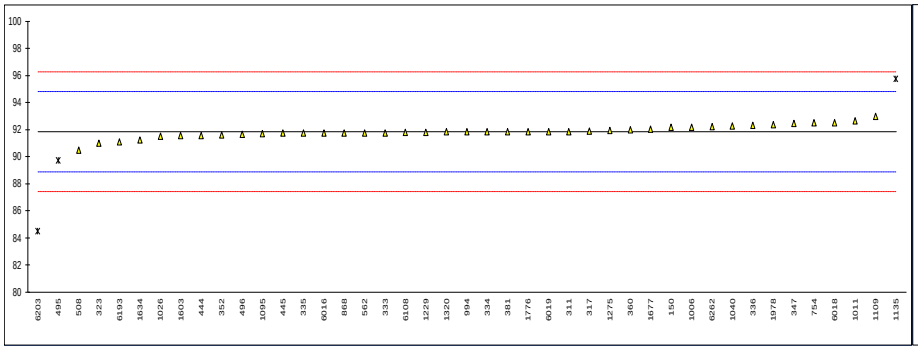
Determination of Ethane on sample #20200; results in %mol/mol

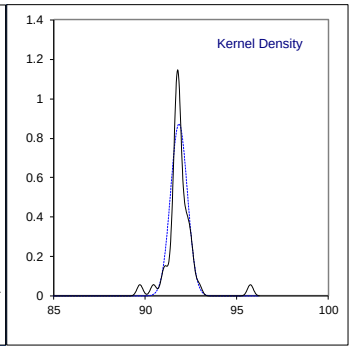
lab	method	value	mark	z(targ)	remarks
150	D2163	0.191		-0.08	
171		-----		-----	
311	D2163	0.19		-0.10	
317	D2163	0.18		-0.36	
323	D2163	0.20		0.15	
333	D2163	0.19		-0.10	
334	D2163	0.19		-0.10	
335	D2163	< 0.01		<-4.65	possibly a false negative test result?
336	D2163	0.18		-0.36	
347	D2163	0.201		0.17	
352	EN27941	0.1914		-0.07	
360	EN27941	0.20		0.15	
381	DIN51619	0.192		-0.05	
444	IP405	0.198		0.10	
445	D2163	0.16		-0.86	
495	D2163	0.16	ex	-0.86	test result excluded, see §4.1
496	D2163	0.197		0.07	
508	D2163	0.193056		-0.03	
529		-----		-----	
562	D2163	0.188		-0.15	
754	D2163	0.195		0.02	
868	D2163	0.194		0.00	
994	D2163	0.2102		0.41	
1006	D2163	0.215		0.53	
1011	ISO7941	0.2		0.15	
1026	ISO7941	0.19	C	-0.10	first reported 0.23
1040	DIN51619Mod.	0.196		0.05	
1095	ISO7941	0.19		-0.10	
1109	IP405	0.28		2.17	
1135	D2163	0.62	R(0.01)	10.75	
1229	IP473	0.18		-0.36	
1275	EN27941	0.209		0.38	
1320	D2163	0.193		-0.03	
1469		-----		-----	
1603		0.1900		-0.10	
1634	ISO7941	0.20		0.15	
1677		0.194		0.00	
1776	EN27941	0.197	C	0.07	first reported 0.654
1978	D2163	0.2080		0.35	
6016	GOST10679	0.1918		-0.06	
6018	EN27941	0.2067		0.32	
6019	ISO7941	0.1281		-1.67	
6108	D2163	0.1911		-0.08	
6142		-----		-----	
6193	D2163	0.20		0.15	
6203	EN27941	0.1144	ex	-2.01	test result excluded, see §4.1
6262	D2163	0.1696		-0.62	
	normality	not OK			
	n	39			
	outliers	1 (+2 ex)			
	mean (n)	0.1941			
	st.dev. (n)	0.02039			
	R(calc.)	0.0571			
	st.dev.(D2163:14)	0.03962			
	R(D2163:14)	0.1109			Compare R(EN27941:13(liq)) = 0.3005



Determination of Propane on sample #20200; results in %mol/mol

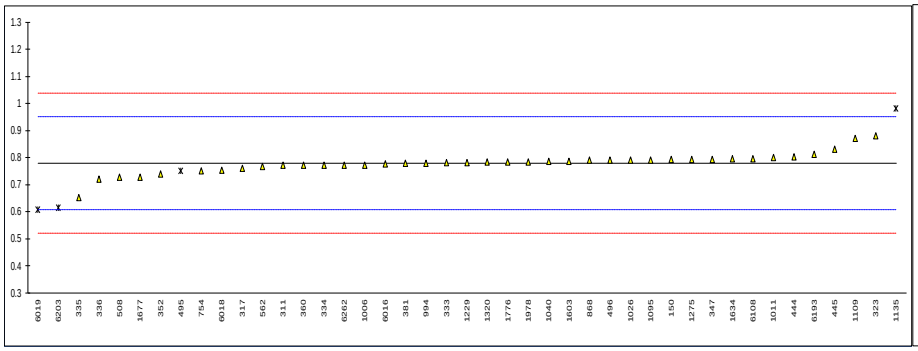
lab	method	value	mark	z(targ)	remarks
150	D2163	92.132		0.20	
171		-----		-----	
311	D2163	91.84		0.00	
317	D2163	91.86		0.01	
323	D2163	90.97		-0.59	
333	D2163	91.74		-0.07	
334	D2163	91.82		-0.02	
335	D2163	91.71		-0.09	
336	D2163	92.27		0.29	
347	D2163	92.449		0.41	
352	EN27941	91.5927		-0.17	
360	EN27941	91.96		0.08	
381	DIN51619	91.82		-0.02	
444	IP405	91.521		-0.22	
445	D2163	91.71		-0.09	
495	D2163	89.71	ex	-1.45	test result excluded, see §4.1
496	D2163	91.631		-0.14	
508	D2163	90.450463		-0.95	
529		-----		-----	
562	D2163	91.728		-0.08	
754	D2163	92.489		0.44	
868	D2163	91.719		-0.08	
994	D2163	91.8071		-0.02	
1006	D2163	92.146		0.21	
1011	ISO7941	92.6		0.51	
1026	ISO7941	91.51	C	-0.23	first reported 93.99
1040	DIN51619Mod.	92.245		0.27	
1095	ISO7941	91.69		-0.10	
1109	IP405	92.93		0.74	
1135	D2163	95.74	R(0.01)	2.65	
1229	IP473	91.79		-0.04	
1275	EN27941	91.895		0.04	
1320	D2163	91.806		-0.03	
1469		-----		-----	
1603		91.5209		-0.22	
1634	ISO7941	91.19		-0.44	
1677		91.984		0.10	
1776	EN27941	91.82	C	-0.02	first reported 95.803
1978	D2163	92.3483		0.34	
6016	GOST10679	91.7166		-0.09	
6018	EN27941	92.4913		0.44	
6019	ISO7941	91.8362		0.00	
6108	D2163	91.7472		-0.07	
6142		-----		-----	
6193	D2163	91.06		-0.53	
6203	EN27941	84.4891	R(0.01)	-5.00	
6262	D2163	92.1746		0.23	
	normality	suspect			
	n	40			
	outliers	2 (+1 ex)			
	mean (n)	91.8430			
	st.dev. (n)	0.45791			
	R(calc.)	1.2821			
	st.dev.(D2163:14)	1.47197			
	R(D2163:14)	4.1215			Compare R(EN27941:13(liq)) = 1.0245

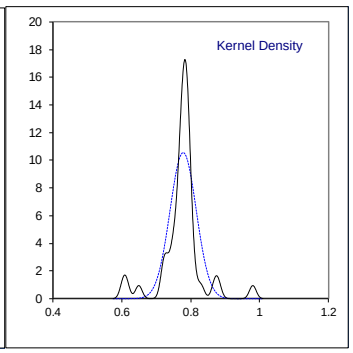




Determination of Propene on sample #20200; results in %mol/mol

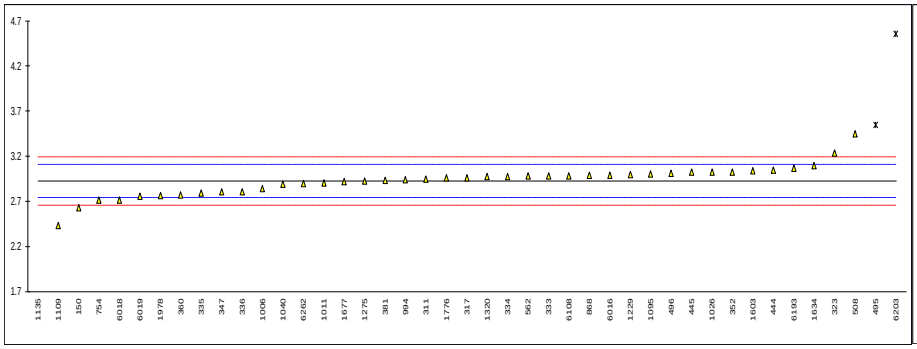
lab	method	value	mark	z(targ)	remarks
150	D2163	0.791		0.15	
171		-----		-----	
311	D2163	0.77		-0.10	
317	D2163	0.76		-0.21	
323	D2163	0.88		1.18	
333	D2163	0.78		0.02	
334	D2163	0.77		-0.10	
335	D2163	0.65		-1.49	
336	D2163	0.72		-0.68	
347	D2163	0.793		0.17	
352	EN27941	0.7382		-0.47	
360	EN27941	0.77		-0.10	
381	DIN51619	0.777		-0.02	
444	IP405	0.802		0.27	
445	D2163	0.83		0.60	
495	D2163	0.75	ex	-0.33	test result excluded, see §4.1
496	D2163	0.789		0.12	
508	D2163	0.725490		-0.61	
529		-----		-----	
562	D2163	0.765		-0.16	
754	D2163	0.750		-0.33	
868	D2163	0.789		0.12	
994	D2163	0.7774		-0.01	
1006	D2163	0.771		-0.09	
1011	ISO7941	0.8		0.25	
1026	ISO7941	0.79	C	0.13	first reported 0.81
1040	DIN51619Mod.	0.785		0.08	
1095	ISO7941	0.79		0.13	
1109	IP405	0.87		1.06	
1135	D2163	0.98	G(0.01)	2.34	
1229	IP473	0.78		0.02	
1275	EN27941	0.791		0.15	
1320	D2163	0.782		0.04	
1469		-----		-----	
1603		0.7853		0.08	
1634	ISO7941	0.795		0.19	
1677		0.727		-0.60	
1776	EN27941	0.782	C	0.04	first reported 0.994
1978	D2163	0.7820		0.04	
6016	GOST10679	0.7753		-0.04	
6018	EN27941	0.7519		-0.31	
6019	ISO7941	0.6052	G(0.05)	-2.01	
6108	D2163	0.7953		0.20	
6142		-----		-----	
6193	D2163	0.81		0.37	
6203	EN27941	0.6140	ex	-1.91	test result excluded, see §4.1
6262	D2163	0.7706		-0.09	
	normality	not OK			
	n	39			
	outliers	2 (+2 ex)			
	mean (n)	0.7785			
	st.dev. (n)	0.03785			
	R(calc.)	0.1060			
	st.dev.(D2163:14)	0.08617			
	R(D2163:14)	0.2413			Compare R(EN27941:13(liq)) = 0.2147

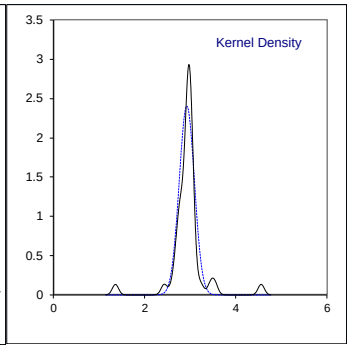




Determination of iso-Butane on sample #20200; results in %mol/mol

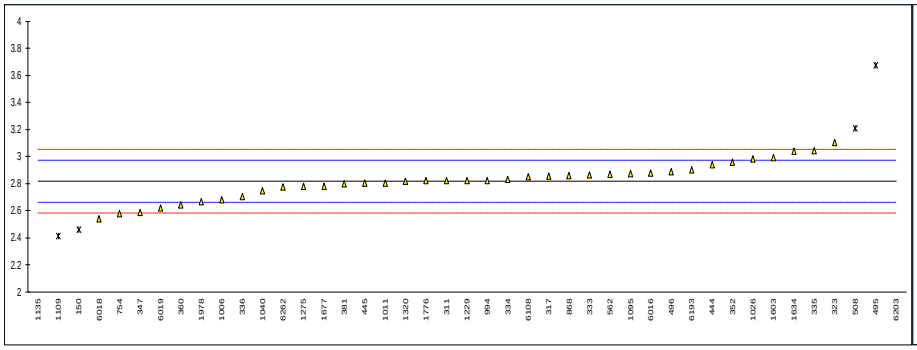
lab	method	value	mark	z(targ)	remarks
150	D2163	2.626		-3.31	
171		-----		-----	
311	D2163	2.94		0.16	
317	D2163	2.96		0.38	
323	D2163	3.23		3.36	
333	D2163	2.98		0.60	
334	D2163	2.97		0.49	
335	D2163	2.79		-1.50	
336	D2163	2.80		-1.39	
347	D2163	2.799		-1.40	
352	EN27941	3.0227		1.07	
360	EN27941	2.77		-1.72	
381	DIN51619	2.927		0.02	
444	IP405	3.042		1.29	
445	D2163	3.02		1.04	
495	D2163	3.54	R(0.05)	6.79	
496	D2163	3.004		0.87	
508	D2163	3.447776		5.77	
529		-----		-----	
562	D2163	2.975		0.55	
754	D2163	2.707		-2.41	
868	D2163	2.985		0.66	
994	D2163	2.9391		0.15	
1006	D2163	2.836		-0.99	
1011	ISO7941	2.9		-0.28	
1026	ISO7941	3.02	C	1.04	first reported 2.23
1040	DIN51619Mod.	2.889		-0.40	
1095	ISO7941	3.00		0.82	
1109	IP405	2.43		-5.47	
1135	D2163	1.36	R(0.01)	-17.29	
1229	IP473	2.99		0.71	
1275	EN27941	2.925		-0.01	
1320	D2163	2.968		0.47	
1469		-----		-----	
1603		3.0316		1.17	
1634	ISO7941	3.09		1.82	
1677		2.914		-0.13	
1776	EN27941	2.955	C	0.33	first reported 1.300
1978	D2163	2.7605		-1.82	
6016	GOST10679	2.9853		0.66	
6018	EN27941	2.7083		-2.40	
6019	ISO7941	2.7509		-1.93	
6108	D2163	2.9815		0.62	
6142		-----		-----	
6193	D2163	3.06		1.49	
6203	EN27941	4.5560	R(0.01)	18.01	
6262	D2163	2.8913		-0.38	
	normality	not OK			
	n	40			
	outliers	3			
	mean (n)	2.9255			
	st.dev. (n)	0.16595			
	R(calc.)	0.4647			
	st.dev.(D2163:14)	0.09053			
	R(D2163:14)	0.2535			Compare R(EN27941:13(liq)) = 0.3886

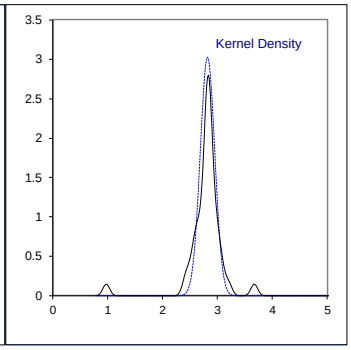




Determination of n-Butane on sample #20200; results in %mol/mol

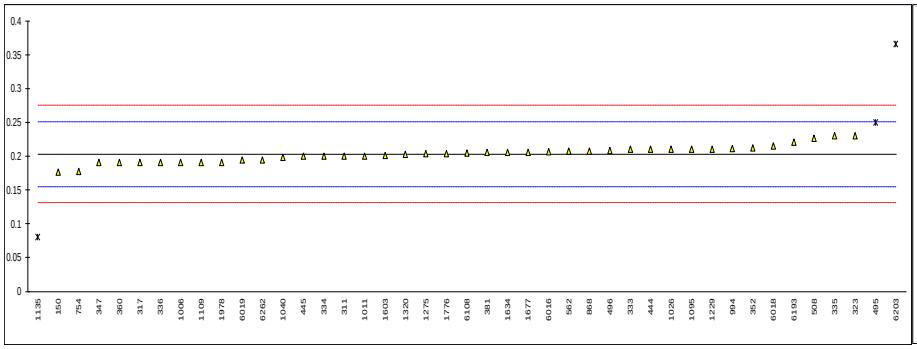
lab	method	value	mark	z(targ)	remarks
150	D2163	2.459	R(0.05)	-4.57	
171		-----		-----	
311	D2163	2.82		0.04	
317	D2163	2.85		0.42	
323	D2163	3.10		3.61	
333	D2163	2.86		0.55	
334	D2163	2.83		0.17	
335	D2163	3.04		2.85	
336	D2163	2.70		-1.49	
347	D2163	2.582		-3.00	
352	EN27941	2.9557		1.77	
360	EN27941	2.64		-2.26	
381	DIN51619	2.796		-0.27	
444	IP405	2.939		1.56	
445	D2163	2.80		-0.22	
495	D2163	3.67	R(0.01)	10.89	
496	D2163	2.887		0.89	
508	D2163	3.204858	R(0.05)	4.95	
529		-----		-----	
562	D2163	2.865		0.61	
754	D2163	2.575		-3.09	
868	D2163	2.855		0.49	
994	D2163	2.8207		0.05	
1006	D2163	2.677		-1.79	
1011	ISO7941	2.8		-0.22	
1026	ISO7941	2.98	C	2.08	first reported 1.95
1040	DIN51619Mod.	2.744		-0.93	
1095	ISO7941	2.87		0.68	
1109	IP405	2.41	R(0.05)	-5.20	
1135	D2163	0.97	R(0.01)	-23.58	
1229	IP473	2.82		0.04	
1275	EN27941	2.775		-0.54	
1320	D2163	2.816		-0.01	
1469		-----		-----	
1603		2.9908		2.22	
1634	ISO7941	3.035		2.78	
1677		2.778		-0.50	
1776	EN27941	2.819	C	0.03	first reported 0.939
1978	D2163	2.6655		-1.93	
6016	GOST10679	2.8743		0.73	
6018	EN27941	2.5347		-3.60	
6019	ISO7941	2.6148		-2.58	
6108	D2163	2.8475		0.39	
6142		-----		-----	
6193	D2163	2.90		1.06	
6203	EN27941	5.9969	R(0.01)	40.60	
6262	D2163	2.7722		-0.57	
	normality	OK			
	n	37			
	outliers	6			
	mean (n)	2.8170			
	st.dev. (n)	0.13203			
	R(calc.)	0.3697			
	st.dev.(D2163:14)	0.07832			
	R(D2163:14)	0.2193			Compare R(EN27941:13(liq)) = 0.3886

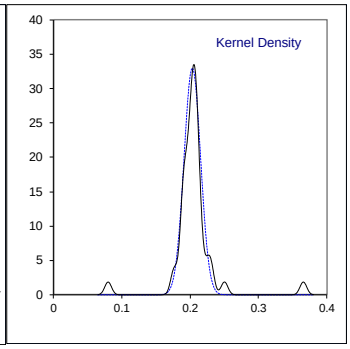




Determination of 1-Butene on sample #20200; results in %mol/mol

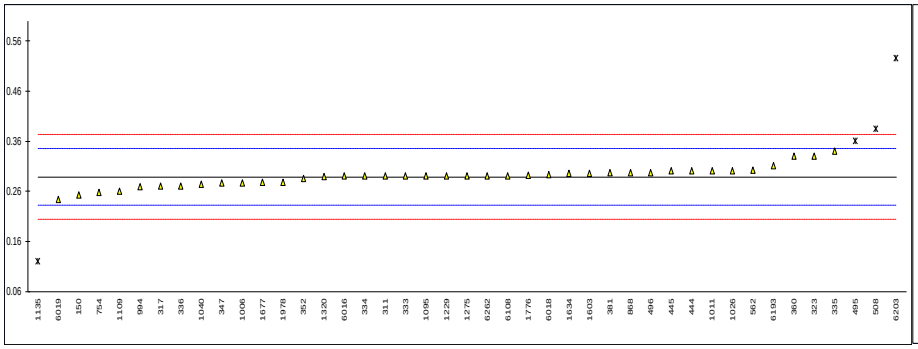
lab	method	value	mark	z(targ)	remarks
150	D2163	0.176		-1.13	
171		-----		-----	
311	D2163	0.20		-0.13	
317	D2163	0.19		-0.54	
323	D2163	0.23		1.12	
333	D2163	0.21		0.29	
334	D2163	0.20		-0.13	
335	D2163	0.23		1.12	
336	D2163	0.19		-0.54	
347	D2163	0.19		-0.54	
352	EN27941	0.2122		0.38	
360	EN27941	0.19		-0.54	
381	DIN51619	0.205		0.08	
444	IP405	0.210		0.29	
445	D2163	0.20		-0.13	
495	D2163	0.25	ex	1.96	test result excluded, see §4.1
496	D2163	0.208		0.21	
508	D2163	0.225739		0.95	
529		-----		-----	
562	D2163	0.207		0.17	
754	D2163	0.177		-1.09	
868	D2163	0.207		0.17	
994	D2163	0.2113		0.35	
1006	D2163	0.190		-0.54	
1011	ISO7941	0.2		-0.13	
1026	ISO7941	0.21	C	0.29	first reported 0.15
1040	DIN51619Mod.	0.198		-0.21	
1095	ISO7941	0.21		0.29	
1109	IP405	0.19		-0.54	
1135	D2163	0.08	R(0.01)	-5.13	
1229	IP473	0.21		0.29	
1275	EN27941	0.203		0.00	
1320	D2163	0.202		-0.04	
1469		-----		-----	
1603		0.2008		-0.09	
1634	ISO7941	0.205		0.08	
1677		0.205		0.08	
1776	EN27941	0.203	C	0.00	first reported 0.084
1978	D2163	0.1902		-0.53	
6016	GOST10679	0.2066		0.15	
6018	EN27941	0.2151		0.50	
6019	ISO7941	0.1942		-0.37	
6108	D2163	0.2046		0.07	
6142		-----		-----	
6193	D2163	0.22		0.71	
6203	EN27941	0.3652	R(0.01)	6.76	
6262	D2163	0.1942		-0.37	
	normality	OK			
	n	40			
	outliers	2 (+1 ex)			
	mean (n)	0.2030			
	st.dev. (n)	0.01209			
	R(calc.)	0.0338			
	st.dev.(D2163:14)	0.02398			
	R(D2163:14)	0.0671			Compare R(EN27941:13(liq)) = 0.1610

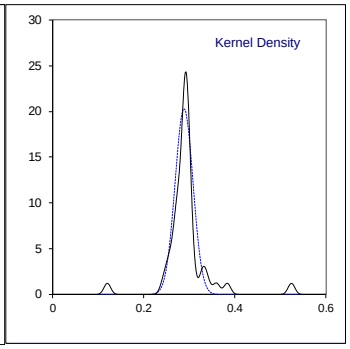




Determination of iso-Butene on sample #20200; results in %mol/mol

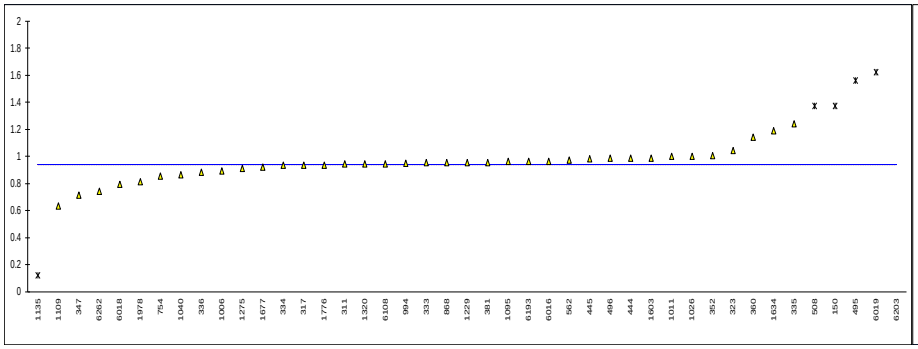
lab	method	value	mark	z(targ)	remarks
150	D2163	0.252		-1.31	
171		-----		-----	
311	D2163	0.29		0.04	
317	D2163	0.27		-0.67	
323	D2163	0.33		1.47	
333	D2163	0.29		0.04	
334	D2163	0.29		0.04	
335	D2163	0.34		1.82	
336	D2163	0.27		-0.67	
347	D2163	0.276		-0.45	
352	EN27941	0.2844		-0.15	
360	EN27941	0.33		1.47	
381	DIN51619	0.296		0.26	
444	IP405	0.300		0.40	
445	D2163	0.30		0.40	
495	D2163	0.36	R(0.05)	2.54	
496	D2163	0.297		0.29	
508	D2163	0.383773	R(0.01)	3.38	
529		-----		-----	
562	D2163	0.302		0.47	
754	D2163	0.257		-1.13	
868	D2163	0.297		0.29	
994	D2163	0.2682		-0.73	
1006	D2163	0.276		-0.45	
1011	ISO7941	0.3		0.40	
1026	ISO7941	0.30	C	0.40	first reported 0.21
1040	DIN51619Mod.	0.274		-0.52	
1095	ISO7941	0.29		0.04	
1109	IP405	0.26		-1.02	
1135	D2163	0.12	R(0.01)	-6.01	
1229	IP473	0.29		0.04	
1275	EN27941	0.290		0.04	
1320	D2163	0.289		0.01	
1469		-----		-----	
1603		0.2957		0.25	
1634	ISO7941	0.295		0.22	
1677		0.277		-0.42	
1776	EN27941	0.291	C	0.08	first reported 0.122
1978	D2163	0.2780		-0.38	
6016	GOST10679	0.2896		0.03	
6018	EN27941	0.2922		0.12	
6019	ISO7941	0.2434		-1.61	
6108	D2163	0.2906		0.07	
6142		-----		-----	
6193	D2163	0.31		0.76	
6203	EN27941	0.5249	R(0.01)	8.40	
6262	D2163	0.2900		0.04	
	normality	suspect			
	n	39			
	outliers	4			
	mean (n)	0.2887			
	st.dev. (n)	0.01964			
	R(calc.)	0.0550			
	st.dev.(D2163:14)	0.02810			
	R(D2163:14)	0.0787			Compare R(EN27941:13(liq)) = 0.1610

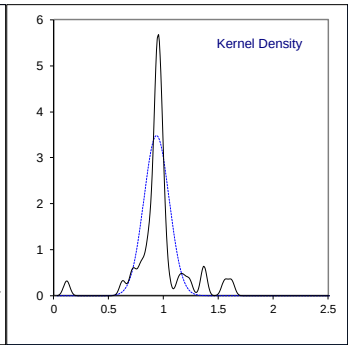




Determination of n-Pentane on sample #20200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.371	R(0.05)	-----	
171		-----		-----	
311	D2163	0.94		-----	
317	D2163	0.93		-----	
323	D2163	1.04		-----	
333	D2163	0.95		-----	
334	D2163	0.93		-----	
335	D2163	1.24		-----	
336	D2163	0.88		-----	
347	D2163	0.71		-----	
352	EN27941	1.0030		-----	
360	EN27941	1.14		-----	
381	DIN51619	0.953		-----	
444	IP405	0.983		-----	
445	D2163	0.98		-----	
495	D2163	1.56	R(0.05)	-----	
496	D2163	0.983		-----	
508	D2163	1.368845	R(0.05)	-----	
529		-----		-----	
562	D2163	0.970		-----	
754	D2163	0.850		-----	
868	D2163	0.950		-----	
994	D2163	0.9461		-----	
1006	D2163	0.889		-----	
1011	ISO7941	1.0		-----	
1026	ISO7941	1.00	C	-----	first reported 0.43
1040	DIN51619Mod.	0.860		-----	
1095	ISO7941	0.96		-----	
1109	IP405	0.63		-----	
1135	D2163	0.12	R(0.01)	-----	
1229	IP473	0.95		-----	
1275	EN27941	0.909		-----	
1320	D2163	0.942		-----	
1469		-----		-----	
1603		0.9849		-----	
1634	ISO7941	1.185		-----	
1677		0.917		-----	
1776	EN27941	0.934	C	-----	first reported 0.106
1978	D2163	0.8076		-----	
6016	GOST10679	0.9606		-----	
6018	EN27941	0.7893		-----	
6019	ISO7941	1.6218	R(0.05)	-----	
6108	D2163	0.9422		-----	
6142		-----		-----	
6193	D2163	0.96		-----	
6203	EN27941	3.3155	R(0.01)	-----	
6262	D2163	0.7375		-----	
	normality	not OK			
	n	37			
	outliers	6			
	mean (n)	0.9388			
	st.dev. (n)	0.11472			
	R(calc.)	0.3212			
	st.dev.(D2163:14)	(0.03239)			
	R(D2163:14)	(0.0907)			Compare R(EN27941:13(liq)) = 0.3131





Determination of iso-Pentane on sample #20200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	<0.01		-----	
171		-----		-----	
311		-----		-----	
317	D2163	<0.01		-----	
323	D2163	< 0.01		-----	
333	D2163	<0.01		-----	
334	D2163	<0.01		-----	
335	D2163	< 0.01		-----	
336	D2163	<0.01		-----	
347		-----		-----	
352		-----		-----	
360	EN27941	< 0.1		-----	
381	DIN51619	0.034		-----	as per DIN51619 result is <0.1
444	IP405	0.003		-----	rounded result is <0.1
445	D2163	<0.01		-----	
495	D2163	<0,01		-----	
496	D2163	0.003		-----	rounded result is <0.01
508	D2163	0.000000		-----	
529		-----		-----	
562		-----		-----	
754		-----		-----	
868	D2163	0.003		-----	
994	D2163	<0.01		-----	
1006	D2163	0		-----	
1011	ISO7941	< 0.1		-----	
1026	ISO7941	0.00		-----	
1040	DIN51619Mod.	0.003		-----	
1095	ISO7941	0.00		-----	rounded result <0.1
1109	IP405	0.00		-----	
1135	D2163	<0.01		-----	
1229	IP473	0		-----	
1275	EN27941	0.003		-----	
1320		-----		-----	
1469		-----		-----	
1603		-----		-----	
1634	ISO7941	0.00		-----	
1677		0.003		-----	rounded result <0.01
1776		-----		-----	
1978		-----		-----	
6016		-----		-----	
6018		-----		-----	
6019		-----		-----	
6108	D2163	<0.01		-----	
6142		-----		-----	
6193	D2163	0		-----	
6203	EN27941	0.0241		-----	
6262	D2163	<0.01		-----	
	n	27			
	mean (n)	<0.01			

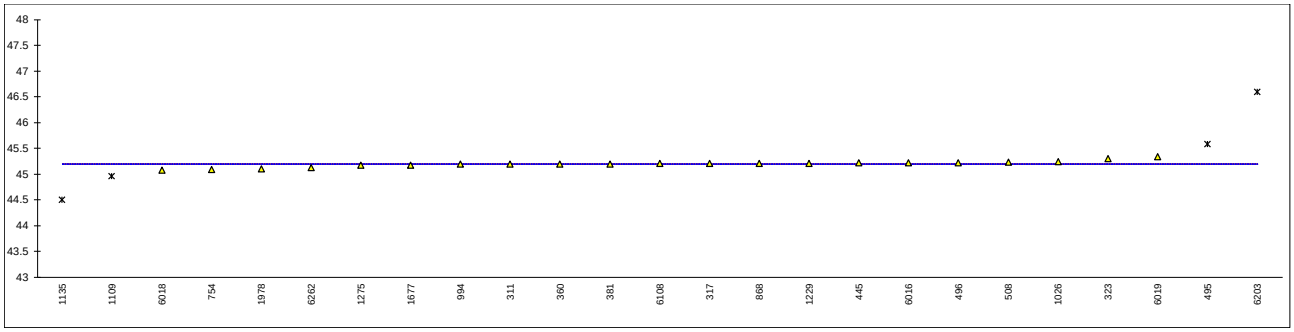
Total of reported composition (normalized) test results; results in %mol/mol

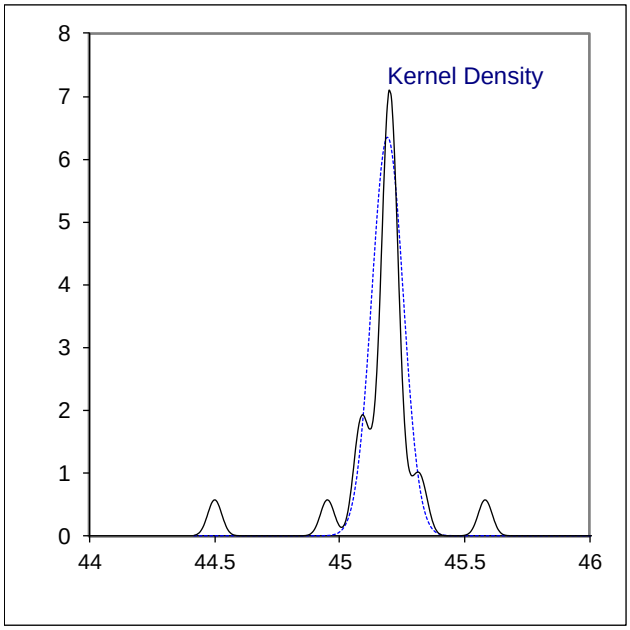
lab	method	value	remarks
150	D2163	100.00	
171		-----	
311	D2163	99.99	
317	D2163	100.00	
323	D2163	99.98	
333	D2163	100.00	
334	D2163	100.00	
335	D2163	100.00	
336	D2163	100.01	
347	D2163	100.00	
352	EN27941	100.00	
360	EN27941	100.00	
381	DIN51619	100.00	
444	IP405	100.00	
445	D2163	100.00	
495	D2163	100.00	
496	D2163	100.00	
508	D2163	100.00	
529		-----	
562	D2163	100.00	
754	D2163	100.00	
868	D2163	100.00	
994	D2163	99.98	
1006	D2163	100.00	
1011	ISO7941	**100.80**	Not 100%
1026	ISO7941	100.00	
1040	DIN51619Mod.	100.19	
1095	ISO7941	100.00	
1109	IP405	100.00	
1135	D2163	99.99	
1229	IP473	100.01	
1275	EN27941	100.00	
1320	D2163	100.00	
1469		-----	
1603		100.00	
1634	ISO7941	100.00	
1677		100.00	
1776	EN27941	100.00	
1978	D2163	100.04	
6016	GOST10679	100.00	
6018	EN27941	99.99	
6019	ISO7941	99.99	
6108	D2163	100.00	
6142		-----	
6193	D2163	**99.52**	Not 100%
6203	EN27941	100.00	
6262	D2163	100.00	

Determination of Molar Mass on sample #20200; results in g/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311	D2598	45.19		-----	
317	INH-001	45.2		-----	
323	D2598	45.30		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
336		-----		-----	
347		-----		-----	
352		-----		-----	
360	ISO8973	45.19		-----	
381	ISO8973	45.1943		-----	
444		-----		-----	
445	D2163	45.209		-----	
495	D2163	45.58	ex	-----	test result excluded, see §4.1
496	D2163	45.216		-----	
508	D2598	45.228119	E	-----	calculation difference, iis calculated 45.444
529		-----		-----	
562		-----		-----	
754	D2421	45.085		-----	
868	D2598	45.20		-----	
994	D2163	45.1845		-----	
1006		-----		-----	
1011		-----		-----	
1026	ISO8973	45.24	C	-----	first reported 44.80
1040		-----		-----	
1095		-----		-----	
1109	ISO8973	44.950	R(0.05)	-----	
1135	D2598	44.5	ex	-----	test result excluded, see §4.1
1229	ISO8973	45.20		-----	
1275	EN589	45.166	C	-----	first reported 45.137
1320		-----		-----	
1469		-----		-----	
1603		-----		-----	
1634		-----		-----	
1677	D2163	45.169		-----	
1776		-----		-----	
1978	D2598	45.0903		-----	
6016		45.21		-----	
6018	ISO8973	45.07		-----	
6019	ISO8973	45.33		-----	
6108	D2163	45.1987		-----	
6142		-----		-----	
6193		-----		-----	
6203	ISO8973	46.5921	ex	-----	test result excluded, see §4.1
6262	D2163	45.12		-----	
					iis calc. based on ALL reported composition results: *)
	normality	OK			OK
	n	21			36
	outliers	1 (+3 ex)			2 (+5 ex)
	mean (n)	45.190			45.193
	st.dev. (n)	0.0628	RSD = 0.14%		0.0609 RSD = 0.13%
	R(calc.)	0.176			0.170
	compare				
	R(iis19S03P)	0.083			0.072
	R(iis18S03P)	0.098			0.173

*) Calculated by iis based on relative molecular masses as given in table 2 of ASTM D2421:19
NB. Effect of different factors of ASTM D2421:19 and ISO8973:97/IP432:00(2017) on the calculation is very small

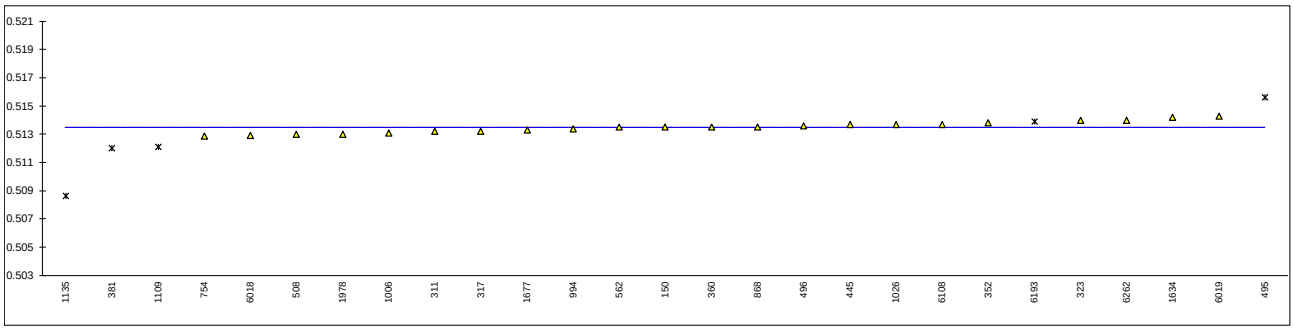

48
47.5
47
46.5
46
45.5
45
44.5
44
43.5
43
1135
1109
6018
754
1978
6262
1275
1677
994
311
360
381
6108
317
868
1229
445
6016
496
508
1026
323
6019
495
6203

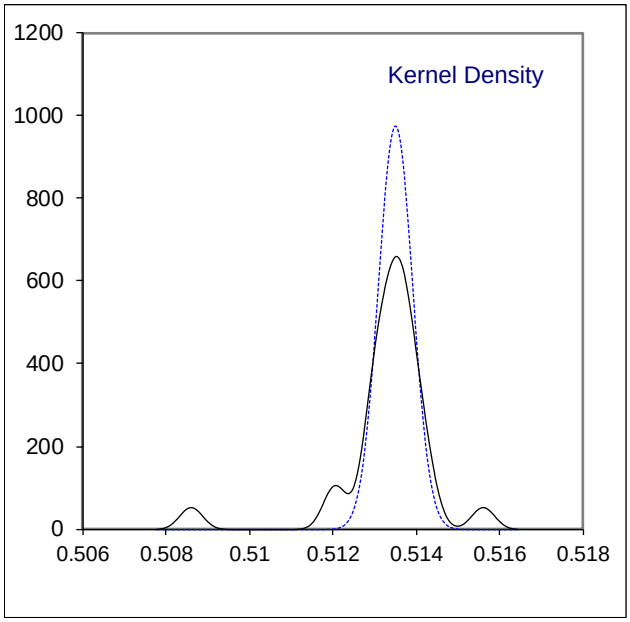

Kernel Density
8
7
6
5
4
3
2
1
0
44
44.5
45
45.5
46

Determination of Relative Density at 60/60°F on sample #20200;

lab	method	value	mark	z(targ)	remarks
150	D2598	0.5135		-----	
171		-----		-----	
311	D2598	0.5132		-----	
317	INH-001	0.5132		-----	
323	D2598	0.514		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
336		-----		-----	
347		-----		-----	
352	ISO8973	0.5138		-----	
360	D2598	0.5135		-----	
381	D2598	0.512	DG(0.05)	-----	
444		-----		-----	
445	ISO8973	0.5137		-----	
495	D2598	0.5156	ex	-----	test result excluded, see §4.1
496	D2598	0.51359		-----	
508	D2598	0.513		-----	
529		-----		-----	
562	D2598	0.5135		-----	
754	D2598	0.51285		-----	
868	D2598	0.5135		-----	
994	D2598	0.5134		-----	
1006	D2598	0.5131		-----	
1011		-----		-----	
1026	ISO8973	0.5137	C	-----	first reported 0.5112
1040		-----		-----	
1095		-----		-----	
1109	D2598	0.5121	DG(0.05)	-----	
1135	D2598	0.5086	ex	-----	test result excluded, see §4.1
1229		-----		-----	
1275		-----		-----	
1320		-----		-----	
1469		-----		-----	
1603		-----		-----	
1634	ISO8973	0.5142		-----	
1677	D2598	0.51331		-----	
1776		-----		-----	
1978	D2598	0.5130		-----	
6016		-----		-----	reported 1.5603 as Relative Density at 20°C
6018	ISO8973	0.5129		-----	
6019	ISO8973	0.5143		-----	
6108	D2598	0.5137		-----	
6142		-----		-----	
6193	ISO8973	0.5139	ex	-----	test result excluded, see §4.1
6203		-----		-----	
6262	D2598	0.5140		-----	
					iis calc. based on ALL reported composition results: *)
	normality	OK			OK
	n	22			36
	outliers	2 (+3 ex)			2 (+5 ex)
	mean (n)	0.51350			0.51344
	st.dev. (n)	0.000409	RSD = 0.08%		0.000366 RSD = 0.07%
	R(calc.)	0.00115			0.00102
	compare				
	R(iis19S03P)	0.00039			0.00042
	R(iis18S03P)	0.00129			0.00081

*) Calculated by iis based on relative densities at 60°F (15.6°C) as given in table 1 of ASTM D2598:16
N.B. Effect of different factors from ASTM D2598:16 and ISO8973:97/IP432:00(2017) on the calculation is very small.


0.521
0.519
0.517
0.515
0.513
0.511
0.509
0.507
0.505
0.503
1135
381
1109
754
6018
508
1978
1006
311
317
1677
994
562
150
360
868
496
445
1026
6108
352
6193
323
6262
1634
6019
495


Kernel Density
1200
1000
800
600
400
200
0
0.506
0.508
0.51
0.512
0.514
0.516
0.518

Determination of Absolute Vapor Pressure at 100°F on sample #20200; results in psi

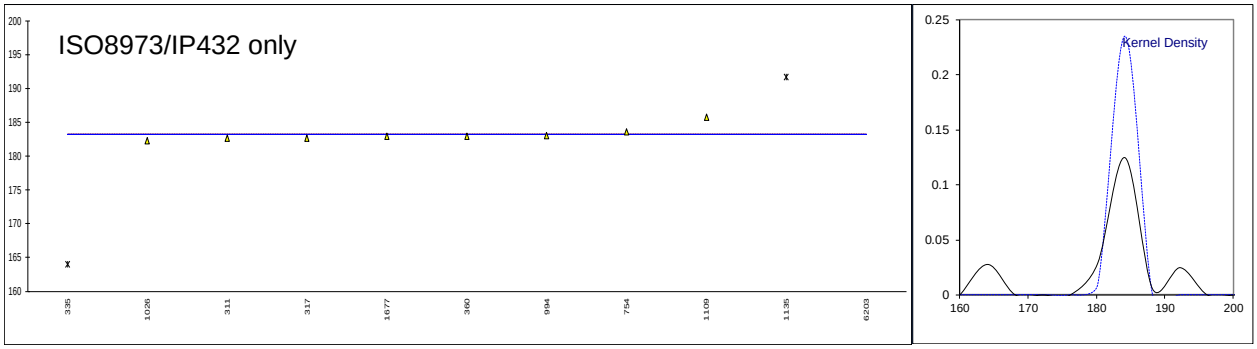
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171		-----		-----	-----		-----	
311	ISO8973	182.6		-----	-----		-----	
317	ISO8973	182.6		-----	-----		-----	
323		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334		-----		-----	-----		-----	
335	ISO8973	164.0	E, G(0.01)	-----	-----		-----	calc. difference, iis calc. 180.82
336		-----		-----	-----		-----	
347	D2598	-----		-----	180		-----	
352		-----		-----	-----		-----	
360	ISO8973	182.9		-----	-----		-----	
381	D2598	-----		-----	180.28	E	-----	calc. difference, iis calc. 178.60
444		-----		-----	-----		-----	
445		-----		-----	-----		-----	
495	D2598	-----		-----	174.9	ex	-----	test result excluded, see §4.1
496	D2598	-----		-----	178.35		-----	
508		-----		-----	-----		-----	
529		-----		-----	-----		-----	
562	D2598	-----		-----	182	E	-----	calc. difference, iis calc. 178.44
754	ISO8973	183.53		-----	-----		-----	
868	D2598	-----		-----	178.5		-----	
994	ISO8973	182.97		-----	-----		-----	
1006	D2598	-----		-----	179.2		-----	
1011		-----		-----	-----		-----	
1026	ISO8973	182.2	C	-----	-----		-----	first reported 186.1
1040		-----		-----	-----		-----	
1095		-----		-----	-----		-----	
1109	ISO8973	185.73		-----	-----		-----	
1135	ISO8973	191.6	ex	-----	-----		-----	test result excluded, see §4.1
1229		-----		-----	-----		-----	
1275		-----		-----	-----		-----	
1320		-----		-----	-----		-----	
1469		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1677	ISO8973	182.854		-----	-----		-----	
1776		-----		-----	-----		-----	
1978	D2598	-----		-----	179.1200		-----	
6016		-----		-----	-----		-----	
6018		-----		-----	-----		-----	
6019		-----		-----	-----		-----	
6108		-----		-----	-----		-----	
6142		-----		-----	-----		-----	
6193		-----		-----	-----		-----	
6203	ISO8973	1180.420	U, ex	-----	-----		-----	see remark below this table
6262		-----		-----	-----		-----	

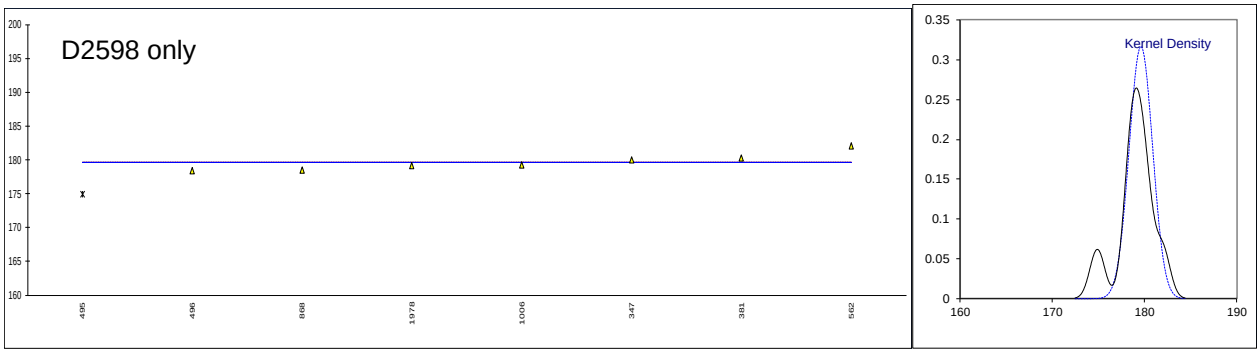
Lab 6203: test result excluded, see §4.1, U = possibly reported in kPa

	ISO8973/IP432		D2598	
normality	not OK		unknown	
n	8		7	
outliers	1 (+2 ex)		0 (+1 ex)	
mean (n)	183.173		179.636	
st.dev. (n)	1.1011	RSD = 0.6%	1.2607	RSD = 0.7%
R(calc.)	3.083		3.530	
compare				
R(iis19S03P)	0.252		0.801	
R(iis18S03P)	2.785		2.239	

	iis calc. based on ALL *) reported composition results		iis calc. based on ALL **) reported composition results	
normality	OK		suspect	
n	35		36	
outliers	3 (+5 ex)		2 (+5 ex)	
mean (n)	182.725		178.598	
st.dev. (n)	0.4998	RSD = 0.3%	0.6194	RSD = 0.3%
R(calc.)	1.399		1.734	
compare				
R(iis19S03P)	0.967		0.964	
R(iis18S03P)	0.872		1.007	

*) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table A.1 of ISO8973:97/IP432:00(2017)
**) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table 1 of ASTM D2598:16.





Determination of Relative Vapor Pressure at 100°F on sample #20200; results in psi

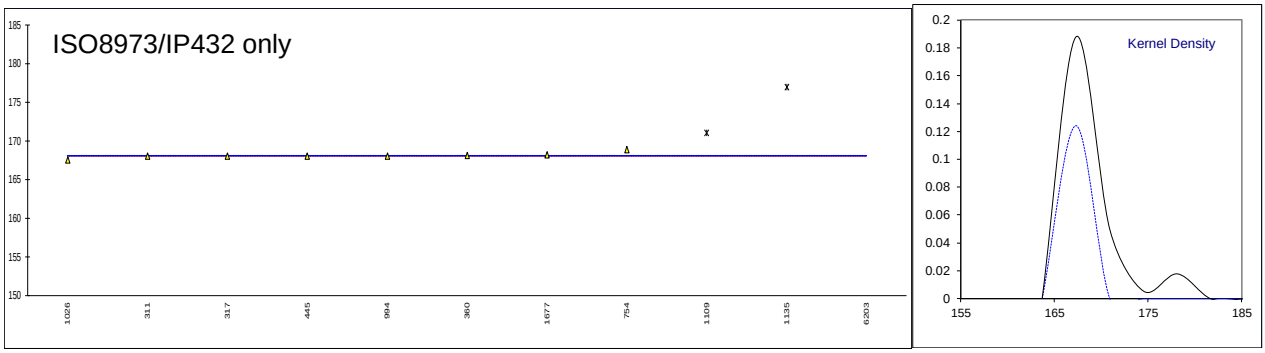
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150	D2598	-----		-----	164.0		-----	
171		-----		-----	-----		-----	
311	ISO8973	168		-----	-----		-----	
317	ISO8973	168.0		-----	-----		-----	
323	D2598	-----		-----	162.88		-----	
333		-----		-----	-----		-----	
334		-----		-----	-----		-----	
335		-----		-----	-----		-----	
336		-----		-----	-----		-----	
347	D2598	-----		-----	165		-----	
352		-----		-----	-----		-----	
360	ISO8973	168.1		-----	-----		-----	
381	D2598	-----		-----	165.58	E	-----	calc. difference, iis calc. 163.91
444		-----		-----	-----		-----	
445	ISO8973	168		-----	-----		-----	
495	D2598	-----		-----	160.2	ex	-----	test result excluded, see §4.1
496	D2598	-----		-----	163.65		-----	
508	D2598	-----		-----	164	E	-----	calc. difference, iis calc. 161.58
529		-----		-----	-----		-----	
562	D2598	-----		-----	164		-----	
754	ISO8973	168.84		-----	-----		-----	
868	D2598	-----		-----	163.8		-----	
994	ISO8973	168.02		-----	-----		-----	
1006	D2598	-----		-----	164.5		-----	
1011		-----		-----	-----		-----	
1026	ISO8973	167.5	C	-----	-----		-----	first reported 171.4
1040		-----		-----	-----		-----	
1095		-----		-----	-----		-----	
1109	ISO8973	171.04	D(0.05)	-----	-----		-----	
1135	ISO8973	176.9	ex	-----	-----		-----	test result excluded, see §4.1
1229		-----		-----	-----		-----	
1275		-----		-----	-----		-----	
1320		-----		-----	-----		-----	
1469		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1677	ISO8973	168.158		-----	-----		-----	
1776		-----		-----	-----		-----	
1978	D2598	-----		-----	165.1979		-----	
6016		-----		-----	-----		-----	
6018		-----		-----	-----		-----	
6019		-----		-----	-----		-----	
6108	D2598	-----		-----	163.8234		-----	
6142		-----		-----	-----		-----	
6193		-----		-----	-----		-----	
6203	ISO8973	1079	U, ex	-----	-----		-----	see remark below this table
6262	D2598	-----		-----	166.7	E	-----	calc. difference, iis calc. 164.47

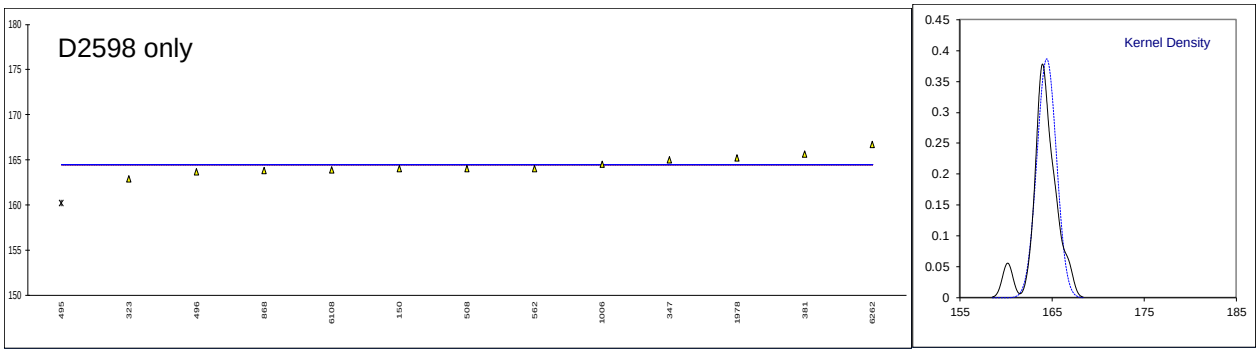
Lab 6203: test result excluded, see §4.1, U = possibly reported in kPa

	ISO8973/IP432		D2598	
normality	not OK		OK	
n	8		12	
outliers	1 (+2 ex)		1 (+1 ex)	
mean (n)	168.077		164.428	
st.dev. (n)	0.3671	RSD = 0.2%	1.0324	RSD = 0.6%
R(calc.)	1.028		2.891	
compare				
R(iis19S03P)	0.259		1.270	
R(iis18S03P)	2.086		2.040	

	iis calc. based on ALL *) reported composition results		iis calc. based on ALL **) reported composition results	
normality	OK		suspect	
n	35		36	
outliers	3 (+5 ex)		2 (+5 ex)	
mean (n)	168.029		163.902	
st.dev. (n)	0.4998	RSD = 0.3%	0.6194	RSD = 0.4%
R(calc.)	1.399		1.734	
compare				
R(iis19S03P)	0.967		0.964	
R(iis18S03P)	1.470		1.593	

*) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table A.1 of ISO8973:97/IP432:00(2017)
**) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table 1 of ASTM D2598:16.

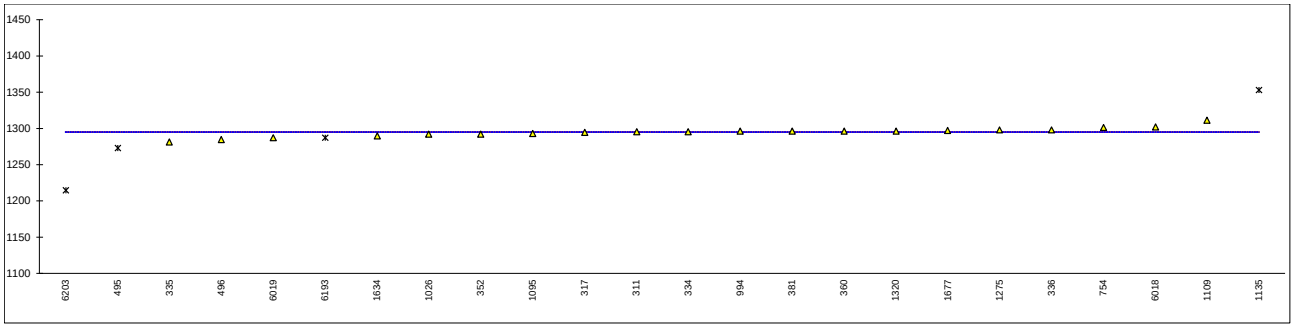


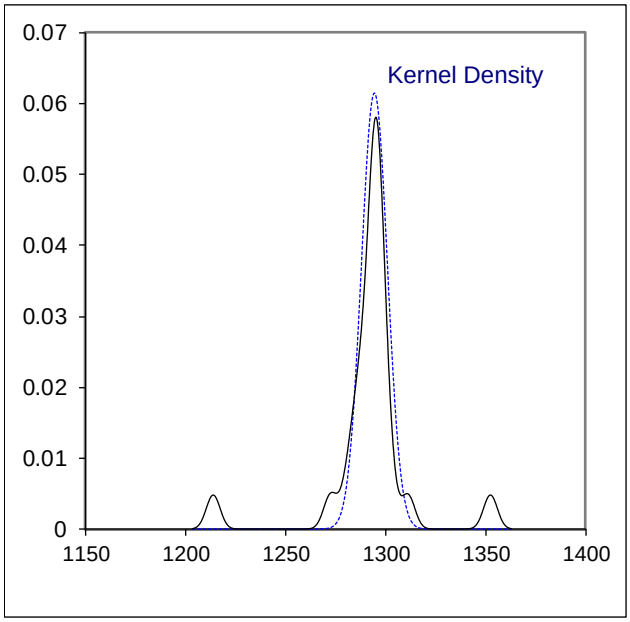


Determination of Absolute Vapor Pressure at 40°C on sample #20200; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311	ISO8973	1295		-----	
317	ISO8973	1294		-----	
323		-----		-----	
333		-----		-----	
334	ISO8973	1295		-----	
335	ISO8973	1281		-----	
336	ISO8973	1298		-----	
347		-----		-----	
352	ISO8973	1292		-----	
360	ISO8973	1296		-----	
381	ISO8973	1296		-----	
444		-----		-----	
445		-----		-----	
495	ISO8973	1272.7	ex	-----	test result excluded, see §4.1
496	ISO8973	1284.23	E	-----	calculation difference, iis calculated 1293.32
508		-----		-----	
529		-----		-----	
562		-----		-----	
754	ISO8973	1300.58		-----	
868		-----		-----	
994	ISO8973	1295.84		-----	
1006		-----		-----	
1011		-----		-----	
1026	ISO8973	1291.6	C	-----	first reported 1318.3
1040		-----		-----	
1095	ISO8973	1293		-----	
1109	ISO8973	1311.37		-----	
1135	ISO8973	1352.6	ex	-----	test result excluded, see §4.1
1229		-----		-----	
1275	EN589	1297.5	C	-----	first reported 1365.7
1320	ISO8973	1296		-----	
1469		-----		-----	
1603		-----		-----	
1634	ISO8973	1289.325		-----	
1677	ISO8973	1296.8		-----	
1776		-----		-----	
1978		-----		-----	
6016		-----		-----	
6018	ISO8973	1302		-----	
6019	ISO8973	1287		-----	
6108		-----		-----	
6142		-----		-----	
6193	ISO8973	1287	ex	-----	test result excluded, see §4.1
6203	ISO8973	1214.048	ex	-----	test result excluded, see §4.1
6262		-----		-----	
					iis calc. based on ALL reported composition results: *)
	normality	suspect			OK
	n	20			35
	outliers	0 (+4 ex)			3 (+5 ex)
	mean (n)	1294.612			1294.962
	st.dev. (n)	6.4932	RSD = 0.5%		3.5202 RSD = 0.3%
	R(calc.)	18.181			9.857
	compare				
	R(iis19S03P))	4.81			6.89
	R(iis18S03P)	8.61			10.39

*) Calculated by iis based on the Vapor Pressure factors at 40°C as given in table A.1 of ISO8973:97/IP432:00(2017)


1450
1400
1350
1300
1250
1200
1150
1100
6203
495
335
496
6019
6193
1634
1026
352
1095
317
311
334
994
381
360
1320
1677
1275
336
754
6018
1109
1135

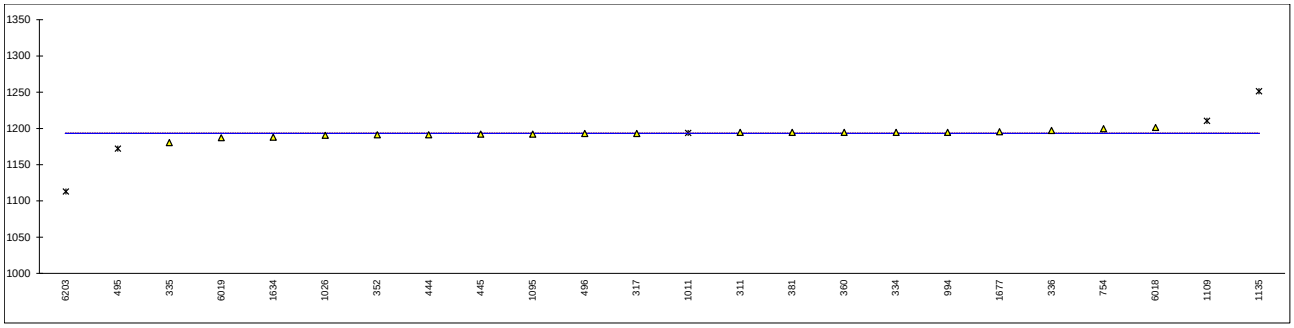

Kernel Density
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1150
1200
1250
1300
1350
1400

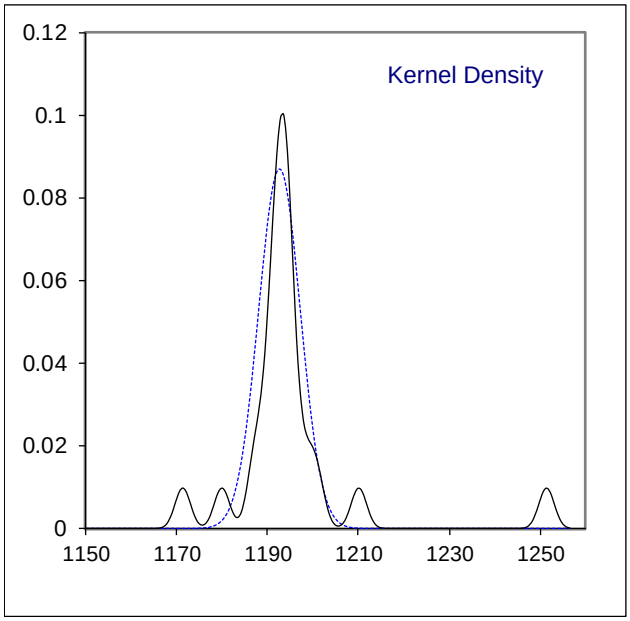
Determination of Relative Vapor Pressure at 40°C on sample #20200; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311	ISO8973	1194		-----	
317	ISO8973	1193		-----	
323		-----		-----	
333		-----		-----	
334	ISO8973	1194		-----	
335	ISO8973	1180		-----	
336	ISO8973	1197		-----	
347		-----		-----	
352	ISO8973	1191		-----	
360	ISO8973	1194		-----	
381	ISO8973	1194		-----	
444	ISO8973	1191.2		-----	
445	ISO8973	1191.5		-----	
495	ISO8973	1171.4	ex	-----	test result excluded, see §4.1
496	ISO8973	1192.90		-----	
508		-----		-----	
529		-----		-----	
562		-----		-----	
754	ISO8973	1199.25		-----	
868		-----		-----	
994	ISO8973	1194.54		-----	
1006		-----		-----	
1011	ISO8973	1193.7	E, ex	-----	see remark below this table
1026	ISO8973	1190.3	C	-----	first reported 1217.0
1040		-----		-----	
1095	ISO8973	1192		-----	
1109	ISO8973	1210.07	G(0.05)	-----	
1135	ISO8973	1251.3	ex	-----	test result excluded, see §4.1
1229		-----		-----	
1275		-----		-----	
1320		-----		-----	
1469		-----		-----	
1603		-----		-----	
1634	ISO8973	1188		-----	
1677	ISO8973	1195.5		-----	
1776		-----		-----	
1978		-----		-----	
6016		-----		-----	
6018	ISO8973	1201		-----	
6019	ISO8973	1187		-----	
6108		-----		-----	
6142		-----		-----	
6193		-----		-----	
6203	ISO8973	1113	ex	-----	test result excluded, see §4.1
6262		-----		-----	
					iis calc. based on ALL reported composition results: *)
	normality	not OK			OK
	n	19			35
	outliers	1 (+4 ex)			3 (+5 ex)
	mean (n)	1192.642			1193.637
	st.dev. (n)	4.5767			3.5202
	R(calc.)	12.815	RSD = 0.4%		9.857 RSD = 0.3%
	compare				
	R(iis19S03P))	5.44			6.89
	R(iis18S03P)	10.79			10.39

Lab 1011: test result excluded, see §4.1, calculation difference, iis calculated 1204.56

*) Calculated by iis based on the Vapor Pressure factors at 40°C as given in table A.1 of ISO8973:97/IP432:00(2017)


1350
1300
1250
1200
1150
1100
1050
1000
6203
495
335
6019
1634
1026
352
444
445
1095
496
317
1011
311
381
360
334
994
1677
336
754
6018
1109
1135


Kernel Density
0.12
0.1
0.08
0.06
0.04
0.02
0
1150
1170
1190
1210
1230
1250

Determination of Motor Octane Number, MON on sample #20200;

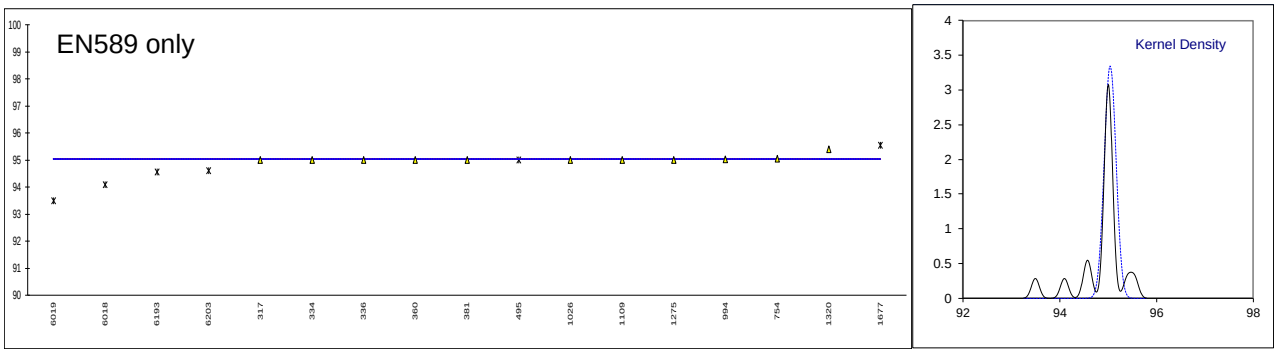
lab	method	EN589	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171		-----		-----	-----		-----	
311		-----		-----	-----		-----	
317	EN589	95.0		-----	-----		-----	
323		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334	EN589	95.0		-----	-----		-----	
335		-----		-----	-----		-----	
336	EN589	95.0		-----	-----		-----	
347		-----		-----	-----		-----	
352		-----		-----	-----		-----	
360	EN589	95.0		-----	-----		-----	
381	EN589	95.0		-----	-----		-----	
444		-----		-----	-----		-----	
445		-----		-----	-----		-----	
495	EN589	95.0	ex	-----	-----		-----	test result excluded, see §4.1
496	D2598	-----		-----	96.262		-----	
508	D2598	-----		-----	96.5	E	-----	see remark below this table
529		-----		-----	-----		-----	
562	D2598	-----		-----	96.0		-----	
754	EN589	95.06		-----	-----		-----	
868	D2598	-----		-----	96.4		-----	
994	EN589	95.03		-----	-----		-----	
1006		-----		-----	-----		-----	
1011		-----		-----	-----		-----	
1026	EN589	95.00	C	-----	-----		-----	first reported 95.12
1040		-----		-----	-----		-----	
1095		-----		-----	-----		-----	
1109	EN589	95.0		-----	-----		-----	
1135	D2598	-----		-----	94.3	E, ex	-----	see remark below this table
1229		-----		-----	-----		-----	
1275	EN589	95.0	C	-----	-----		-----	first reported 94.8
1320	EN589	95.4	E	-----	-----		-----	see remark below this table
1469		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1677	EN589	95.55	E, G(0.05)	-----	-----		-----	see remark below this table
1776		-----		-----	-----		-----	
1978	D2598	-----		-----	95.0483	E, G(0.05)	-----	see remark below this table
6016		-----		-----	-----		-----	
6018	EN589	94.1	E, G(0.01)	-----	-----		-----	see remark below this table
6019	EN589	93.5	E, G(0.05)	-----	-----		-----	see remark below this table
6108	D2598	-----		-----	96.0357	E	-----	see remark below this table
6142		-----		-----	-----		-----	
6193	EN589	94.553	ex	-----	-----		-----	test result excluded, see §4.1
6203	EN589	94.6	ex	-----	-----		-----	test result excluded, see §4.1
6262		-----		-----	-----		-----	

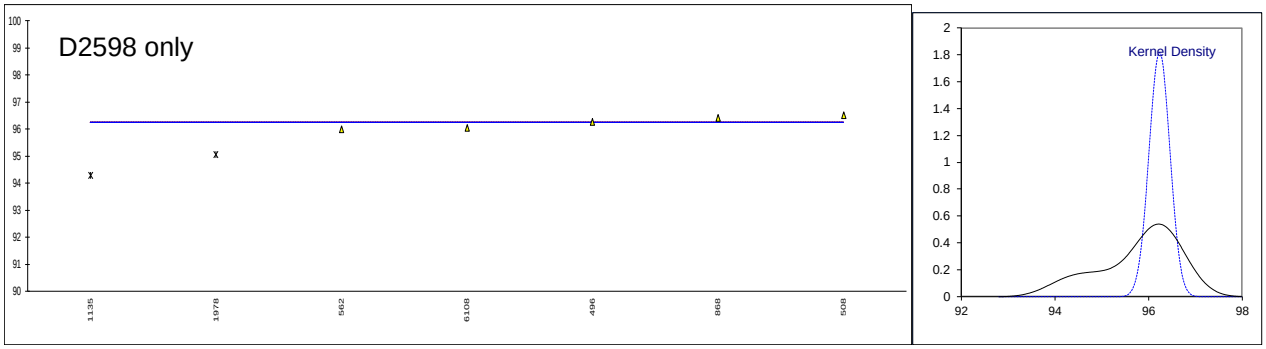
Lab 508: calculation difference, iis calculated with D2598 96.07
Lab 1135: test result excluded, see §4.1, calculation difference, iis calculated with D2598 96.85
Lab 1320: calculation difference, iis calculated with EN589 95.02
Lab 1677: calculation difference, iis calculated with EN589 95.04
Lab 1978: calculation difference, iis calculated with D2598 96.37 and with EN589 95.08
Lab 6018: calculation difference, iis calculated with EN589 95.04
Lab 6019: calculation difference, iis calculated with EN589 95.02
Lab 6108: calculation difference, iis calculated with D2598 96.29

	EN589		D2598	
normality	not OK		unknown	
n	11		5	
outliers	3 (+3 ex)		1 (+1 ex)	
mean (n)	95.045		96.240	
st.dev. (n)	0.1194	RSD = 0.1%	(0.2197)	(RSD = 0.2%)
R(calc.)	0.334		(0.615)	
compare				
R(iis19S03P)	0.033		(1.003)	
R(iis18S03P)	0.445		(1.229)	

	iis calc. based on ALL *) reported composition results		iis calc. based on ALL **) reported composition results	
normality	suspect		suspect	
n	37		38	
outliers	1 (+5 ex)		0 (+5 ex)	
mean (n)	95.024		96.285	
st.dev. (n)	0.0237	RSD = 0.02%	0.0869	RSD = 0.09%
R(calc.)	0.066		0.243	
compare				
R(iis19S03P)	0.050		0.057	
R(iis18S03P)	0.049		0.064	

*) Calculated by iis based on MON factors given in table B.1 of EN589:18.
**) Calculated by iis based on MON factors given in table 1 of ASTM D2598:16. This method does not mention MON factors for iso-Butene. For iso-Butene the value of 83.5 of cis-2-Butene is used in the calculations in analogy of the MON factors of the other components.



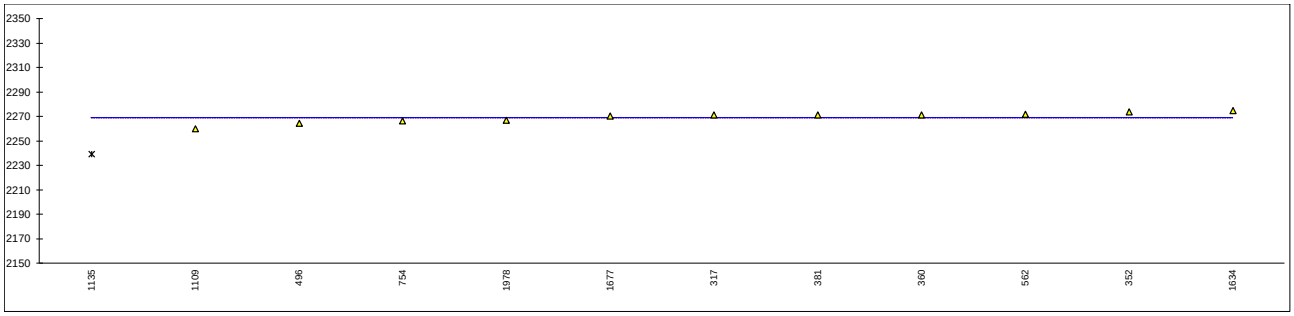


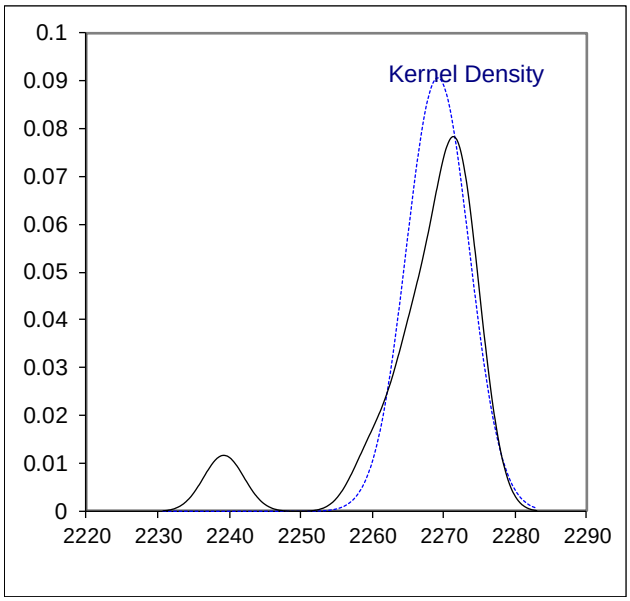
Determination of Ideal Gross Heating Value at 14.696 psia and 60°F on sample #20200; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311		-----		-----	
317	D3588	2271.08		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
336		-----		-----	
347		-----		-----	
352	D3588	2273.5623		-----	
360	D3588	2271.47		-----	
381	D3588	2271.35		-----	
444		-----		-----	
445		-----		-----	
495		-----		-----	
496	D3588	2264.36	E	-----	calculation difference, iis calculated 2272.38
508		-----		-----	
529		-----		-----	
562	D3588	2271.9		-----	
754	D3588	2266.38		-----	
868		-----		-----	
994		-----		-----	
1006		-----		-----	
1011		-----		-----	
1026		-----		-----	
1040		-----		-----	
1095		-----		-----	
1109	D3588	2259.90		-----	
1135	D3588	2239.3	E, ex	-----	see remark below this table
1229		-----		-----	
1275		-----		-----	
1320		-----		-----	
1469		-----		-----	
1603		-----		-----	
1634	D3588	2274.55		-----	
1677	D3588	2270.24		-----	
1776		-----		-----	
1978	D3588	2266.6108		-----	
6016		-----		-----	reported 96.28 as IGHV at 14.696 psia and 20°C
6018		-----		-----	
6019		-----		-----	
6108		-----		-----	
6142		-----		-----	
6193		-----		-----	
6203		-----		-----	
6262		-----		-----	
					iis calc. based on ALL reported composition results: *)
	normality	OK			OK
	n	11			36
	outliers	0 (+1 ex)			2 (+5 ex)
	mean (n)	2269.219			2271.362
	st.dev. (n)	4.4034	RSD = 0.2 %		2.8490 RSD = 0.1%
	R(calc.)	12.330			7.977
	compare				
	R(iis19S03P))	3.30			3.35
	R(iis18S03P)	11.72			8.13

Lab 1135: test result excluded, see §4.1, calculation difference, iis calculated 2232.89

*) Calculated by iis based on the Ideal Gross Heating Value at 14.696 psia/60°F factors given in table 1 of ASTM D3588:98(2017).


2350
2330
2310
2290
2270
2250
2230
2210
2190
2170
2150
1135
1109
496
754
1978
1677
317
381
360
562
352
1634

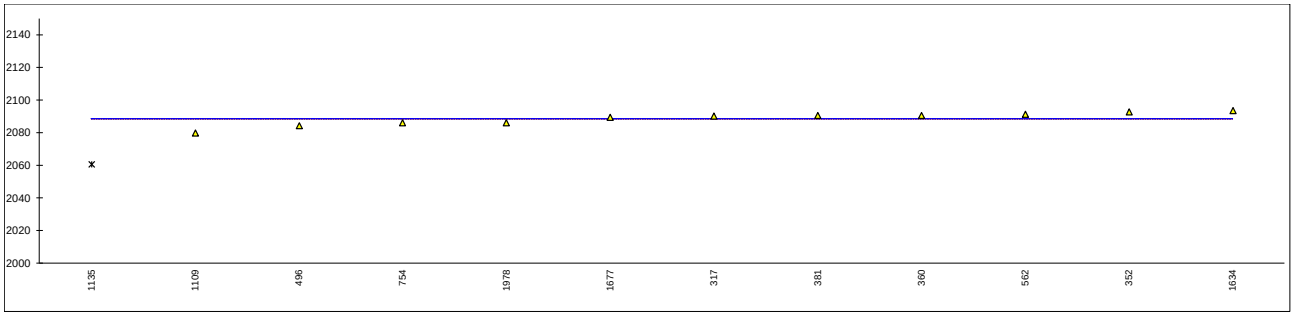

Kernel Density
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2220
2230
2240
2250
2260
2270
2280
2290

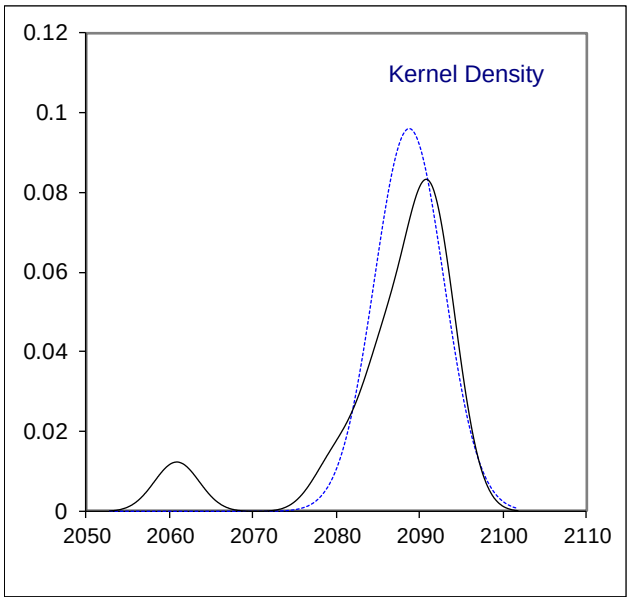
Determination of Ideal Net Heating Value at 14.696 psia and 60°F on sample #20200; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311		-----		-----	
317	D3588	2090.40		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
336		-----		-----	
347		-----		-----	
352	D3588	2092.6669		-----	
360	D3588	2090.76		-----	
381	D3588	2090.67		-----	
444		-----		-----	
445		-----		-----	
495		-----		-----	
496	D3588	2084.14	E	-----	calculation difference, iis calculated 2091.64
508		-----		-----	
529		-----		-----	
562	D3588	2091.3		-----	
754	D3588	2085.99		-----	
868		-----		-----	
994		-----		-----	
1006		-----		-----	
1011		-----		-----	
1026		-----		-----	
1040		-----		-----	
1095		-----		-----	
1109	D3588	2079.77		-----	
1135	D3588	2060.8	E, ex	-----	see remark below this table
1229		-----		-----	
1275		-----		-----	
1320		-----		-----	
1469		-----		-----	
1603		-----		-----	
1634	D3588	2093.66		-----	
1677	D3588	2089.61		-----	
1776		-----		-----	
1978	D3588	2086.2101		-----	
6016		-----		-----	reported 88.62 as INHV at 14.696 psia and 20°C
6018		-----		-----	
6019		-----		-----	
6108		-----		-----	
6142		-----		-----	
6193		-----		-----	
6203		-----		-----	
6262		-----		-----	
					iis calc. based on ALL reported composition results: *)
	normality	OK			OK
	n	11			36
	outliers	0 (+1 ex)			2 (+5 ex)
	mean (n)	2088.653			2090.679
	st.dev. (n)	4.1593	RSD = 0.2 %		2.6574 RSD = 0.1%
	R(calc.)	11.646			7.441
	compare				
	R(iis19S03P))	3.16			3.14
	R(iis18S03P)	11.04			7.59

Lab 1135: test result excluded, see §4.1, calculation difference, iis calculated 2054.79

*) Calculated by iis based on the Ideal Net Heating Value at 14.696 psia/60°F factors given in table 1 of ASTM D3588:98(2017).

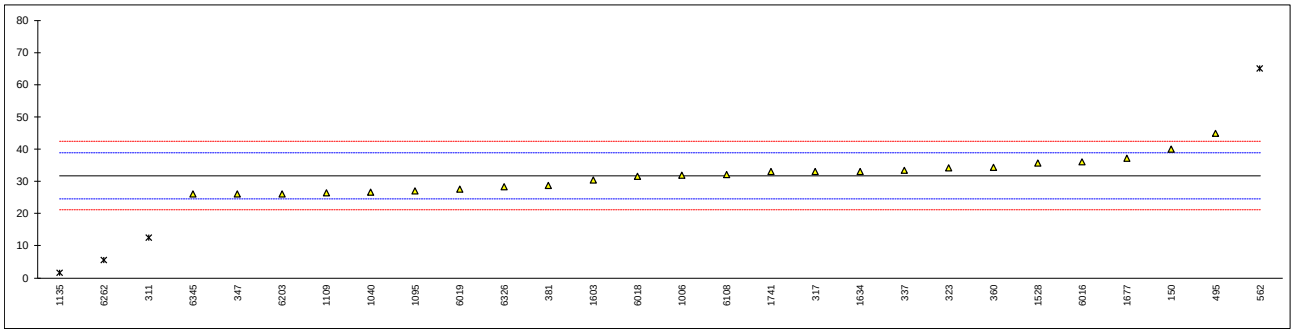

2140
2120
2100
2080
2060
2040
2020
2000
1135
1109
496
754
1978
1677
317
381
360
562
352
1634

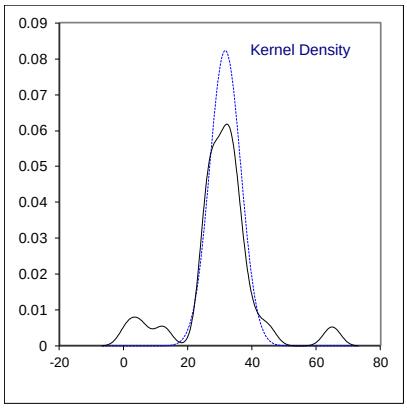

Kernel Density
0.12
0.1
0.08
0.06
0.04
0.02
0
2050
2060
2070
2080
2090
2100
2110

Determination of Total Sulfur on sample #20201; results in mg/kg

lab	method	value	mark	z(targ)	remarks
150	D6667	40.0	C	2.32	first reported 5.3
171		-----		-----	
311	D6667	12.4	C,R(0.05)	-5.45	first reported 6.4
317	D6667	33		0.35	
323	D6667	34		0.63	
337	D6667	33.4	C	0.46	first reported 6.7
347	D6667	26		-1.62	
360	D6667	34.3		0.72	
381	D6667	28.7		-0.86	
445		-----		-----	
495	D6667	44.9		3.70	
562	D6667	65	R(0.05)	9.36	
754		-----		-----	
1006	D6667	31.8		0.01	
1011		-----		-----	
1040	ISO20846	26.5		-1.48	
1095	D6667	27		-1.34	
1109	D6667	26.38		-1.52	
1135	D6667	1.5	R(0.05)	-8.52	
1528	D6667	35.66	C	1.10	first reported 45.66
1603		30.4		-0.38	
1634	D6667	33		0.35	
1677	D6667	37.04		1.49	
1741	D6667	32.9		0.32	
6016	D6667	36.02		1.20	
6018	D6667	31.37		-0.11	
6019	D6667	27.59		-1.17	
6108	D6667	31.995		0.07	
6142		-----		-----	
6203	D6667	26.06		-1.61	
6262	D6667	5.506	R(0.05)	-7.39	
6326	D6667	28.326		-0.97	
6345	D6667	25.93		-1.64	

normality	OK
n	24
outliers	4
mean (n)	31.761
st.dev. (n)	4.8448
R(calc.)	13.565
st.dev.(D6667:14)	3.5505
R(D6667:14)	9.941





APPENDIX 2

Number of participants per country

Liquified Propane iis20S03P

1 lab in	AUSTRALIA
1 lab in	AZERBAIJAN
3 labs in	BELGIUM
1 lab in	BULGARIA
2 labs in	CHILE
1 lab in	CHINA, People's Republic
1 lab in	DENMARK
1 lab in	EGYPT
1 lab in	ESTONIA
1 lab in	FINLAND
4 labs in	FRANCE
4 labs in	GERMANY
1 lab in	IRELAND
1 lab in	KAZAKHSTAN
1 lab in	MEXICO
3 labs in	NETHERLANDS
1 lab in	PANAMA
6 labs in	PORTUGAL
1 lab in	ROMANIA
1 lab in	RUSSIAN FEDERATION
1 lab in	SERBIA
1 lab in	SLOVAKIA
1 lab in	SPAIN
1 lab in	SWEDEN
1 lab in	TAIWAN
3 labs in	UNITED KINGDOM
2 labs in	UNITED STATES OF AMERICA
1 lab in	VIETNAM

Sulfur (total) in LPG iis20S03S

1 lab in	AUSTRALIA
3 labs in	BELGIUM
1 lab in	BULGARIA
1 lab in	CHILE
1 lab in	ESTONIA
1 lab in	FRANCE
3 labs in	GERMANY
1 lab in	IRELAND
1 lab in	KAZAKHSTAN
1 lab in	MALAYSIA
2 labs in	NETHERLANDS
5 labs in	PORTUGAL
2 labs in	ROMANIA
1 lab in	RUSSIAN FEDERATION
2 labs in	SERBIA
1 lab in	SPAIN
1 lab in	TAIWAN
1 lab in	UNITED KINGDOM
3 labs in	UNITED STATES OF AMERICA
1 lab in	VIETNAM

APPENDIX 3

Abbreviations

C	= final result after checking of first reported suspect test result
D(0.01)	= outlier in Dixon's outlier test
D(0.05)	= straggler in Dixon's outlier test
G(0.01)	= outlier in Grubbs' outlier test
G(0.05)	= straggler in Grubbs' outlier test
DG(0.01)	= outlier in Double Grubbs' outlier test
DG(0.05)	= straggler in Double Grubbs' outlier test
R(0.01)	= outlier in Rosner's outlier test
R(0.05)	= straggler in Rosner's outlier test
E	= calculation difference between reported result and result calculated by iis
ex	= test result excluded from the statistical evaluation
n.a.	= not applicable
n.d.	= not detected
n.e.	= not evaluated
fr.	= first reported
SDS	= safety data sheet

Literature

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